

INDIAN SCIENTISTS

BIOGRAPHICAL SKETCHES

WITH

AN ACCOUNT OF THEIR
RESEARCHES, DISCOVERIES & INVENTIONS

FIRST
EDITION

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SIR JAGADISH CHUNDER BOSE

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PUBLISHERS' NOTE

THE publishers venture to think that as a companion volume to the lives of the many eminent Indians hitherto published by them, this volume containing the sketches of distinguished Indian Scientists will be specially welcome. For the story of the lives and achievements of the famous savants of Science recorded in these pages is proof, if proof were wanted, that "we are of a nation not slow and dull, but of a quick, ingenious and piercing spirit, acute to invent, subtle and sinewy to discourse, not beneath the reach of any point the highest the human capacity can soar to". What is more, modern Indian scientists, brought up in the experimental methods of the West are proving to the world that they could, "pursue science not only for itself but for its application to the benefit of mankind."

Dr. Mahendralal Sircar, perhaps the greatest promoter of scientific enquiry in this coun-

try, and in some respects, the pioneer of Medical Science in India, proved the efficacy of Science in the art of healing. "A Sovereign in the realm of Homœopathy", he laboured for the prevention of diseases and demonstrated "that it is through the laboratories that starvation may be ultimately turned into plenty." Sir J. C. Bose has, by his totally unexpected revelations in plant and animal physiology, created the widest interest in scientific circles. He has thrice astonished the world with the results of his discoveries "first on the property of invisible electric waves, then in revealing the inner and invisible activities of plant life, and thirdly, in establishing the unique generalizations of the unity of all life". European savants have not been slow to recognize that in his investigations on the borderland between physics and physiology "Europe has been left behind by India to which country they would now have to come for inspiration." Indeed, in Sir Jagadish, as has been observed by an English writer, "the culture of thirty centuries has blossomed into a scientific brain of an order-

which we can not duplicate in the west.” Sir P. C. Ray’s researches have fructified in “ an interesting series of compounds” of great commercial value. A Chemist with a considerable record of discoveries to his credit, he may be called a captain of industry as well, as is evidenced by the foundation and growth of the Bengal Chemical and Pharmaceutical works. Sir C. V. Raman’s recent researches in colours and X-rays are fraught with great possibilities in the realm of practical life. Physicists throughout the world are deeply interested in the discovery of what is aptly called the Raman-effect which is characterised as “ a surprising and brilliant discovery with immense potentialities.”

These distinguished Indian scientists have not been content with their own original researches but have created facilities for the continuance of their work. Indeed Sir J. C. Bcse, Sir P. C. Ray and Sir C. V. Raman have been prouder still of the achievements of their pupils who have demonstrated that “ the Indian youth have as much aptitude for, and love of, Science

as the youth of any country in the world." Like the true *gurus* they are, they deem these young workers in the cause of science "the richest legacy to bequeath to this country and the world."

The lives of Prof. Ramachandra and Ramanujan—the mathematicians—show the heights to which speculation in the field of abstract science can be reached in India. For as early as in the middle of the last century, the late Prof. Ramachandra won the recognition of the Universities of Europe by his famous mathematical work on "*Problems of Maxima and Minima*" and only quite recently, Srinivasa Ramanujan, at the early age of 27, developed theories and problems "which it has taken the finest mathematicians of Europe a hundred years to solve, and of which the solution is incomplete to the present day". The story of this infant prodigy and his brilliant achievements reads like a thrilling romance.

Dr. MAHENDRALAL SIRCAR

INTRODUCTION

IT was about the year 1848. There was a young lad of fourteen or fifteen whose poverty and merit had secured for him a free-scholarship in the Hare School, Calcutta. He had an infinite thirst for knowledge and truth, and this inclined him to the study of scientific books. One day, while reading Milner's *Tour through Creation*, he came across the discovery of Sir William Herschell—that the sun was no fixed body in space; but, with his planets and satellites, was in motion and probably around some larger sun. This fragment of truth, grand and astounding as it should have been to the little school lad, immediately drove him out of his study into the long and noisy street where he paced for some time to and fro, observing the heavens with the enthusiasm of a research scholar in his laboratory. The fire of enthusiasm for unravel-

INDIAN SCIENTISTS

ling the mysteries of nature and the laws of Creation was kindled in his mind at that moment. It was not an evanescent emotion, so natural to the soil of his province. It persisted throughout his long life of seventy-one years. It made him dedicate his life to the teaching of the importance of scientific knowledge to his people. It had convinced him that science was an elevating, regenerating subject and hence a predominant factor in any scheme of Indian revival. It enthused him to devote his life to the noble object of creating the necessary facilities for scientific studies in a country stricken with the curse of apathy and indifference to all sublunary concerns. This lad when he had grown to manhood was known as Dr. Mâhendralal Sircar, M.D., C.I.E., D.L. In the following pages, it is proposed to give a sketch of the life and career of this great man.

BIRTH AND PARENTAGE

Paikpara, a village situated in the outskirts of Howrah, is the birth-place of Dr. Mahendralal Sircar. Perhaps no other event associates this village with public

memory. The IMPERIAL GAZETTEER as well as the HOWRAH DISTRICT GAZETTEER have not taken even a passing notice of this small village. Equally insignificant was the parentage of Dr. Sircar. He was born in a family of actual tillers of the soil. There was nothing remarkable about the family. We do not get any reference to the parents of Dr. Sircar either in his writings or in his speeches. Even in later life, when he was creating great institutions and founding scholarships and professorships, he had not been known to have expressed any desire to perpetuate the memory of his father or mother. This was perhaps due to the fact that having lost his parents at a very early age, he had no vivid recollections of either of them. But some peculiar features may be noticed about the authors of his being. The father was hardly two or three years older than his wife ; the latter bore her first child namely, Dr. Sircar, when she was past twenty-four. These are rather unusual circumstances in a Hindu family and especially in Bengal of that time where infant marriage and early motherhood were common features.

Born on the 2nd day of November 1833, Sircar lost his father at the early age of five and his mother four years after. Thus he was left an orphan when he was hardly nine years old. He began to live under the roof of his maternal uncles at Nebutola in Calcutta where he was brought by his mother soon after the death and *Sradh* ceremony of his father at Paikpara. Throughout his life, he cherished with deep emotion this locality endeared by the early associations of his boyhood.

EARLY EDUCATION

In accordance with the Hindu custom, the young lad was put under the care of a Guru Mahasay in a private school to learn the rudiments of Bengali. By diligent application, he soon began to improve in his studies with astonishing rapidity. He displayed such interest in his books that he attracted the attention of his guardians who were encouraged to give him the benefit of English education. The services of Babu Thakurnath Dey were solicited to teach him the alphabet of the English tongue. This circumstance was indeed

godsend. This gentleman who had charge of Sircar in the most pliant and formative years of his life was no ordinary man. He had stamped his personality on the heart of his pupil in indelible lines. We come across several references to this great man in the speeches and writings of Sircar. I have met a gentleman, a relative of Dr. Sircar, who was affected with evident emotion when I mentioned the mere name of Thakurnath. He did not belong to that order of mercenary flunkies who, with a smattering of ill-digested English and Bengali, always pretend to fashion young minds while they have more need to forge their own. Indeed, he was a noble soul! He took possession of Sircar with great zeal as of a treasure over which he should exercise all the vigilance he could. He took such an interest in his pupil that he seemed to hope to enjoy the fruits of his efforts; and he looked upon the virtues he cultivated in his new charge as a store laid by for his old age. In a letter which Dr. Sircar wrote to the Calcutta JOURNAL OF MEDICINE, in the month of July 1902, when he was past sixty-nine and slowly

sickening into the darkness of the grave, we find the following reference to his first teacher. He says: "My old master, the late Babu Thakurnath Dey, from whom I received the rudiments of my education, loved me as his own son". What more compliment is needed for a teacher ? What greater reward for Thakurnath Dey ?

AT THE HARE SCHOOL

Sircar passed twelve months with his beloved tutor. During this time, the pecuniary circumstances of his uncles underwent a change for the worse. The eldest of his uncles sought Government service as a travelling-printer and left Calcutta. At that time, David Hare's School was a very popular institution. That great philanthropist was then admitting pupils free of any charge. Through the efforts of his youngest uncle, Mahesh Chandra Ghosh, Sircar was admitted into that school. The memory of David Hare made a very strong impression on the grateful heart of Sircar. He always referred to him as the "father of education in Bengal". He tried even to perpetuate his memory by founding a

professorship in his name at the Science Association. Soon after the death of David Hare in 1842, Sircar fell ill and thus there was a small break in his school career. He was re-admitted by the kindness of Uma Charan Mitter, the then Headmaster of the Institution. The boy finished his school career in the year 1849 when he scored a junior scholarship and was promoted to the Hindu College.

AT THE HINDU COLLEGE

Mr. Sutliffe was the Principal of the Hindu College and Professor of Mathematics. He was by nature very kind and amiable and felt instinctively drawn to his best students by the affection of a parent. He had a keen eye for the detection of genius in his pupils. His wide culture, thorough grasp of his subject, as well as his winning manners made him a very popular Head of the Institution. Such as he was, it happened before long that Sircar became his favourite pupil because he was the best student of his class. He also won the admiration and good-will of Mr. Jones by his close acquaintance with

English literature and Comparative Philosophy. This was the seed-time of Sircar's life. He devoured with cheerful enthusiasm and a freedom which had a charm of its own, all the master-pieces of English literature and the ever-glorious productions of English and European philosophers. He was indeed a voracious reader. This habit continued throughout his life. Thus when we watch him as a humble student in the Hindu College, we feel that, designed as he was for noble ends by His Creator, he was always fired by the idea of his great purpose, and, like the *select few* of Dryden, always moved with "his looks erect and his clay refined." In the midst of the galling duties which, later on, his profession and his public work imposed upon him, he had always made some time every day for the study of such subjects as history, literature and philosophy which not only give polish to a man of science but also add grace and beauty to the general accomplishments of humanity. He had always kept himself in close touch with the literary and scientific movements of the world. Every Foreign Mail

I brought him the latest book-lists from the premier publishers of England, France, Germany and America; and he never failed to order at once for such books as were not only likely to be of interest to him but also of some use in his public life. Thus it was no wonder that the next Foreign Mail which arrived from Europe after his death brought a parcel of books addressed to his great name. Speaking at the Anniversary Celebration of Dr. Mahendralal Sircar in February 1919, Rai Bahadur Dr. Chunilal Bose said : "Dr. Mahendralal Sircar was a man of profound scholarship, not only learned in his own profession and in the various branches of science but well versed in general literature also. Very few of his time possessed such a large library as the Doctor had."

During his later College days, Huxley and Mill were the favourite studies of Sircar. He devoted long and laborious hours to the study of their works. This marked a turning point in his career. I think it was Keightley who wrote that the study of PARADISE LOST should form an era in the life of any man.

Though Sircar was a great student of Milton and used freely to quote from his poems, yet it is doubtful if that poet made any deep impression upon him. The thirst which rose from Sircar's soul asked for the divine drink of science. Being naturally of a scientific bent, he was always searching for concrete truths in his studies. Hence what he used to call the vain and idle fancies of the poets and philosophers did not make any lasting impression upon him. So he soon began to be painfully aware of the unsubstantial nature of the general education which he had been receiving in the College. The more advanced writings of Mill and Huxley were not easily intelligible to him. He thought, he had not made a practical study of the sciences to be able to understand those two authors. So he longed with an anxious heart and a parched-up soul for the divine drink of scientific education.

When such was the change that was slowly creeping upon Sircar in the year 1854, the Hindu College became the Calcutta Presidency College and he was awarded the senior scholarship. But his fierce passion for science

was not to be coaxed into submission by such gifts. He was on the look-out for an institution where his favourite subject was best taught.

The Calcutta Medical College was the only place in those days, where the students were given practical lessons in some of the more important sciences. "Something is better than nothing" thought Sircar. He felt so sorely the need of that kind of training that, like a failing swimmer catching at a straw, he would have entered any institution which professed to teach a practical course in the sciences. He determined at once to leave the Presidency College where "the principal object of education was to teach the pupils how to read and write the English language." This was not possible without struggle. But however the feeling of Sircar was, in the words of a contemporary, that "to be able to speak and to write English and that even incorrectly, after fifteen years of study was not an ability of which any native could be proud." Principal Sutliffe for whom he had the highest regard and esteem became alarmed at what he considered the idiocy of Sircar in the affairs.

of the world. This sympathetic feeling for his pupil soon gave place to one of fierce anger and a sense of great disappointment when he found the stupid boy obstinate in spite of his remonstrances. But the kindly Prof. Jones intervened to pacify Principal Sutliffe and the necessary permission was given to Sircar to join the Medical College which he did in the year 1855.

AT THE MEDICAL COLLEGE

It was in the laboratories of the Medical College that the real genius of Sircar began to display itself. It seemed as if he had at last found his proper level. He appeared to have realised his own self. He became without any delay the pet of all the professors without a single exception. He obtained all the medals, scholarships and prizes in Botany, Physiology, Medicine, Surgery and even Midwifery. His career as a medical student was a brilliant one. A singular instance which occurred during the second year of his stay at the Medical Collage will reveal many of those characteristics which were to glorify him in his later life. One day Sircar was

taking a relation of his (a young boy) to the out-door dispensary of the College, for an eye disease. Dr. Archer, who was Professor for the diseases of the eye, was in the habit of testing the knowledge of the V year students in his Clinique. He used to ask them rather difficult questions on the Anatomy and Physiology of the eye and on the laws of sight. It happened one day that one of the students could not answer a particular question about an obscure point in the anatomy of the eye. Sircar, who was at a distance taking medicine from the compounder, answered the question in a rather loud voice. "Who is that fellow?" asked Dr. Archer. Sircar was proclaimed. The Professor's surprise knew no bounds. He could not contemplate without mixed feelings of astonishment and admiration a second year boy answering "Dr. Archer's questions." The young prodigy was pushed into the Doctor's presence. Questions more difficult and not less comprehensive were showered upon him. The test satisfied the highest expectations of the examiner. The pupil at once became the favourite of the Pro-

essor for the Diseases of the eye. He was asked to attend the Clinique every day to get into closer touch with the subject. Then at the request of the senior students and with the permission of the Principal and the Professors, he delivered a course of lectures on Optics in order to enable his fellow-students to understand the mechanism of the eye as an optical instrument. In the same year, he also delivered a lecture at the Bethune Society on "the adaptation of the human eye to distance". Sircar stayed for six years at the Medical College and passed the L. M. S. Examination in the year 1860. He lost his Gold Medal in Medical Jurisprudence for having stated in answer to a question that the lethal dose of arsenic was much larger than that stated in books and that men were known who had accustomed themselves to taking it in doses of more than a drachm without injury. This was looked upon by the examiner as a gross mistake. The Professor had not evidently read the latest periodical of the time upon whose authority Sircar made his statement.

Sircar married in the year in which he entered the Medical College. His wife bore him his only son the late Dr. Amritalal Sircar, M. S., F. C. S., in the very year in which he had passed the L. M. S. Examination.

In the year 1863, Sircar appeared for the M. D. Examination and came out in the First Class.

DR. SIRCAR AND THE MEDICAL ASSOCIATION

Just about this time, the Bengal Branch of the British Medical Association was established in Calcutta through the indefatigable energy and whole-hearted devotion of Dr. Chakrabarty. Dr. Sircar's brilliant career at the Medical College, and also the new Degree of M. D. that was conferred upon him, made him a prominent figure in the medical world. He had already worked his way through the initial struggles of a new practitioner and was rapidly rising to the acme of popularity and fame. At the inaugural meeting of the Association held at the residence of Dr. Chakrabarty, on the 27th May 1863, Dr. Sircar made a most impressive speech denouncing Homœopathy with remarkable fury in the most contemptuous

terms. He ascribed the rise and "temporary triumph of Homœopaths and other quacks and charlatans" to the indifference and rather wanton neglect of duty on the part of the Allopathic practitioners. The speech was heard with great respect and deference. He was at once elected Secretary of the Association and in 1866 he became one of its Vice-Presidents.

THE GREAT SACRIFICE

Now Dr. Sircar was past thirty years of age. He had won the highest honours in the Medical College and the best encomiums of the Medical profession. He had a large and ever-growing practice and a popularity which made his name a household word in Calcutta. We have already referred to his passion for science. Now we should draw the reader's attention to his deep sincerity and passion for truth. The object of science is to tear off the mysterious garb beneath which the deeper truths of Creation lie-concealed. Thus his passion for Science was really a thirst for truth. The study of science as the study of any other subject can

never be an end in itself. It can only be the means to the perfection of our manliness and womanliness by enabling us to get a clear perception of what is true and what is not true. Dr. Sircar was convinced that the study of science was the only method to get at the fundamental laws that govern the Universe. He could never subscribe to the idea that the study of science generated pride, led to materialism and destroyed religious feelings. In the words of Rev. Father Lafont, that great friend and co-worker of Dr. Sircar, "False science or half knowledge alone puffs up ; true science tends rather to humble human pride by teaching man how little and how imperfectly he knows and understands the works of the Creator." He had followed the object of his life with unflinching devotion and laid his life at the altar of Science and Truth. When Dr. Sircar made his speech at the Medical Association condemning Homœopathy, he knew nothing of the principles upon which that system of cure was based. He describes himself thus : "I was equally with my professional brethren a hater and denouncer of

Homœopathy and perhaps the most furious of them all. Like them, I had no knowledge of it, except from the caricatures of the orthodox opponents. This distorted knowledge derived from misrepresentation of the system, aided by the apparent absurdity of the 'Law of similars' and the Infinitesimal Dose, was enough to justify my refusing to read the works on Homœopathy and 'Homœopaths.'

Soon after, an event happened which changed almost the whole course of his life and career. One day, a friend handed over to him for review a copy of Morgan's Philosophy of Homœopathy. Dr. Sircar took up the work with great earnestness because he wanted to get a clearer idea of the therapeutics of Homœopathy so that he might condemn them in a scientific and authoritative spirit. As he began to read the book, he was taken a helpless captive by the convincing logic of Morgan, the eloquent appeal of Truth and the inevitable conclusions that forced themselves upon his mind with a talismanic charm which was all their own. At once he determined to acquaint

himself thoroughly with the entire theory and practice of Homœopathy. All the standard works on the subject were ordered and they began to pour into his library in a continuous stream from London and New York. He was reading them all with great attention and care. Having mastered the theory, he wanted to test in practice the validity of the principles which he had learnt from the books. He had not long to wait for it. A millionaire of Calcutta, Dr. Rajendralal Dutt, who was the first to introduce Homœopathy into Bengal, was rejoiced at the welcome opportunity of making a convert of the most renowned prince of Allopathic practitioners. He hastened to Dr. Sircar to explain to him the principles of his favourite system. There was no need for his explanations. Dr. Sircar only wanted to observe a few *test cases*, and when he saw the marvellous effects of the accurate treatment by Homœopathy of some apparently incurable cases, he had no hesitation in proclaiming to the world *his conversion* to the doctrines of Hannemann. Dr. Frayer dissuaded him from such a suicidal course. But the appeal of

truth had a greater force with Dr. Sircar than all the weight of such a great personality as Dr. Frayer who had been his Professor and constant well-wisher. He did so by a speech which he delivered at the annual meeting of the Medical Association in Feb. 1867 "On the supposed uncertainty in Medical Science and the relation between Diseases and their Remedial Agents." The scene which followed at the close of his address may be more easily imagined than described. There was an uproar and confusion which was not congenial to any sober discussion. Dr. Sircar's merciless attacks on the empirical nature of the Allopathic system of treatment drove the members of the Association to their wit's end. Attempts were made to expel the offending member who, an hour before, was one of their Vice-Presidents. The conspiracy of the orthodox members won the day. Dr. Sircar became an out-cast. He had forfeited his claim to the membership of the Association on account of the Himalayan offence which he had committed by espousing an obnoxious system. He was a quack Homœopath.

A PERIOD OF

The result of the foregoing events will be better described in the words of Dr. Sircar himself.

"An out cast I actually became from the next day of the meeting. The rumour spread like wild fire that I had lost my reason, and given my adhesion to one of the worst and most absurd of quackeries that has ever come into existence; that I had forgotten my mathematics and now believe that a part was greater than the whole. My patients, and their number was not inconsiderable, who had perfect faith in me, regretted that I had given up my old convictions and one by one forsook me. The loss of my practice was sudden and complete. For six months I had scarcely a case to treat. Even those who received advice and medicine gratis came only to beg me to give the old and not the new medicine."

In the midst of such severe struggles, he heroically held up steadfast to truth. He did not budge an inch even on the advice of sincere friends and well-wishers. His usual reply to those who strongly persuaded him to retract was, "I would rather give up my profession and take to some other calling than disavow truth. I am prepared to brave any contingency that may happen to me for my honest convictions; and to proclaim to the world to the utmost of my power what I believe to be the truth." Thus the 16th February, 1867, will ever remain memorable in the history of the

medical profession in India. On that day, Dr. Sircar stood up for reform in Medicine. He was alone and single-handed. His only strength lay in his heart. He believed that God was Truth and Truth was God. He looked upon himself as an instrument in the hand of God. It was this view of himself and of his mission in life that gave shape to his whole career. He was not afraid of any earthly power. He always felt strong with the strength of God and Truth. So, by his bold stand, he contributed to the growth of toleration and friendliness among the votaries of the different systems in this country.

Thus as it was, in the fitness of things, his practice soon began to look up. Again, his rooms began to get crowded with visitors and patients. People really do not care by what system they are treated provided they are healed and cured. Thus he was able to regain his old practice. Again he sat enthroned in his old position of the premier medical practitioner in Calcutta with the added fame and glory of a great votary of truth who had stood up with fearless courage for

his convictions, under circumstances which would surely have frightened a weaker man into smothering them.

EDITOR AND PROPAGANDIST

Dr. Sircar was singularly free from egotism. In all his speeches we find him shy and shame-faced when forced to speak of himself. He always seemed to take the utmost care that his own greatness did not overshadow the greatness of the cause which he represented. He always stood behind the object for which he worked, like the shadow which follows a substance. He looked upon himself as nothing and his cause as every thing. He never pushed himself to the forefront lest the cause of science should be relegated to the background. Public mind, he knew, had but a small compass. In it two things cannot shine with equal brilliance. Hence he thought that in order to help the cause of science, he must not make his own self very prominent. Thus he was fully aware that self-effacement was the greatest service the scientist could do to advance the cause of science.

Dr. Sircar, speaking of himself with his usual humility in the third person in the presence of the Viceroy and an influential gathering of Native and European gentlemen on the occasion of the laying of the foundation stone of the Vizianagram Laboratory, said, "He was not at all remarkable for intelligence, but had what is called some thirst for knowledge; a little enthusiasm in the pursuit of knowledge; He would feel an unspeakable pleasure in the possession of knowledge and in exact correspondence with the pleasure he felt himself, *had an ardent desire to make others share with him that pleasure.*" This indeed is the key to the character of Dr. Sircar. He had dedicated his life to the search for truth. His study had disciplined and enlarged his faculties. It had brought him into contact with the eternal verities, the living facts and phenomena of nature. He had caught hold of the torch of science and truth. He had resolved not to rest till he had illumined the darkest dog-holes and purged and dispersed the misty clouds of ignorance and superstition from the minds of the people of a country which, he says, "is

down-trodden for centuries by foreign rule and a most de-energising religion." "The Hindu religion", continues Dr. Sircar,

besides having in a pre-eminent degree the grand characteristic of all religions, which is to divorce the mind from the works of God, has, besides, become through the corruptions of successive ages a heterogeneous medley of theology, philosophy, science, and what not, in other words a chaotic mass of crude and undigested and unfounded opinions on all subjects enumerated and enforced in the most dogmatic way imaginable.

Thus we find Dr. Sircar slowly developing into a propagandist of the new system. Before dealing with Dr. Sircar's greatest achievements, the establishment of a temple of science at Calcutta, we must briefly refer to his further services to the cause of Homœopathy. He had already become the most powerful exponent of its principles during his time. Dr. Sircar began to feel the necessity of a proper medium to ventilate his use. He describes his position thus:—

"It became but too evident that I must not content myself with merely practising the new system in which I had recognized the germ of a beneficent truth capable of indefinite development, but that I must help in that development and do all in my power to diffuse a knowledge of it among the profession and the public. I had no hopes of doing it through the medium of the INDIAN MEDICAL GAZETTE, the only orthodox journal in India, whose columns were shut against me even for reply to unfounded charges and slanderous accusations. I thought it not only inadequate but also undignified to do so

through lay journals. I saw that I must have a journal of my own if I was to fulfil my mission at all. The attitude of the Press in India encouraged me to take the risk."

A journal with an unsectarian name, the CALCUTTA JOURNAL OF MEDICINE, was started from January 1868. The work which this journal had accomplished since its inception is fully borne out by the popularity of Homœopathy in Bengal, the disappearance of the spirit of intolerance and foolish orthodoxy from among the members of the healing profession and the importance that has come to be attached to the preventive side of medicine.

THE PROPHET OF A NEW IDEA

It has already been stated more than once that Dr. Sircar's master-passion was for science and that his nature was to let his less fortunate friends share in the benefits of his own education. His transcendent genius coupled with Herculean toil had already brought him into an almost living touch with the master-minds of the world. The Indian educational system placed under the search-light of his enlightened mind appeared to be a "useless rotten affair!" He felt that scientific education was a great

desideratum in his country. This feeling could be traced to his study of Mill, who had exercised the most profound formative influence on his mind. The conviction closely stole upon him and eventually got firm hold of him that "the only method by which the Hindu mind could be developed to its full proportions, was by the cultivation of the Physical Sciences." He was aware of the fact that it was not an easy task that he had put upon himself. He knew of the opposition that he would have to brave. He had already heard of the foolish view of some of his countrymen that when "Science withdrew Enchantment's veil, lovely visions would yield place to cold material laws."

His reply was :—

"The laws of matter are cold only to him who has not the power to appreciate their beauty and their grandeur, their extent and their depth; they are cold only to him who cannot see in them the workings of power and intelligence and goodness, far transcending anything that we can imagine. He is no poet who does not see lovely visions in the revelations of the microscope, the telescope and the spectroscope; who does not see nature assuming lovelier forms by far than had ever been given to the poets' fancy to conceive, when seen in the light of true knowledge or science. The great Coleridge used to attend the lectures of Sir H. Davy that he might enlighten and enrich his imagination; and Coleridge was no ordinary poet. The immortal Goethe—was he less a poet because he was a man of

science as well ; because he gave us the true theory of the plant and of the vertebrate skull; did not he owe his exquisite power of delineating nature and his sublimest flights, subdued by a wonderful objective realism, to his infinite knowledge of natural sciences, botany and osteology in particular? Science, gentlemen, if you will permit me to say it is only living poetry as man creates it is but crystallized science. I do not believe that man's higher nature has suffered in the least from the advance of science. I do not believe that the noblest aspirations of man have received any check by the unfolding of what are falsely called "cold material laws." I do not believe that man's primitive faith and with it his religion has anything to fear from what are ignorantly apprehended to be the encroachment of science. I cannot believe that faith is blind, and religion is irrational ; that is, that they have no basis in the understanding as they have in the heart. What truly constitute man's higher qualities and spiritual nature are, it must be remembered, super-additions to his animal and intellectual natures, which they were intended to crown and not to supersede. They stand enthroned in their conjoint platform ; and the more elevated the platform, the sublimer will be the flight of that which stands on that platform. What St. Paul meant by science falsely so called "is no doubt the false interpretations put upon the revelations of science by scientific men of perverted imagination." I think we cannot make a greater mistake in our estimate of science than to confound it with its votaries. Let us learn to make the distinction, and we shall no longer talk of false science, we shall no longer take the dogmatic assertions of scientific men for the truths of science. Science can never be false. Her foundation is in eternal truth and how can truth be in contradiction with truth ? The contradictions, if any appear to exist, are in our own conceptions. So far from science being in opposition to man's religious convictions, it has been regarded from the remotest ages as the best aid to devotion. Galen said, the best hymn which man can chant in honour of the Creator is to compose a work on anatomy."

With the conviction that the best means for the emancipation of his country from all evils

was not blessed ignorance but blessed knowledge, Dr. Sircar began to teach and enlighten his people. He says of himself:—

“ I am impressed more than ever with the necessity of science cultivation by my countrymen not simply for their improvement but as I have been saying from the very beginning for their very regeneration ; or I would not have sacrificed a life in endeavouring to awaken them to that necessity.”

Even from the material point of view, Dr. Sircar felt no hesitation in fully endorsing the opinion of Sir William Crookes. It is the chemist who must come to the rescue of the threatened communities. It is through the laboratories that starvation may be ultimately turned into plenty. Dr. Sircar began to give gratuitous lectures on scientific subjects to a select audience of destitute students and neighbours of scientific proclivities, at his own house, in the spare hours of the evening. He began to contemplate with pleasure their infinite enthusiasm to hear him. Their increasing numbers enlarged his hopes and enlivened his imagination. His rich fancy began to paint the future of his country in lines of gold. Speaking of Japan, he said, “One Asiatic nation who were

immeasurably our inferiors in ages past when we were in the days of our glory, having understood the spirit of the age, have accordingly acted and have thereby acquired a co-ordinate position with the foremost nations of the world and are now treated by them as honoured allies." Why not India emulate her example? That was his question. So he conceived the idea of founding an institution for the study of the physical sciences, to fill up the long-felt want of the natives of India. Without further delay he issued in the August number of the CALCUTTA JOURNAL OF MEDICINE, 1869, an article on the desirability of a national institution for the cultivation of science by the natives of India. This article couched in the superb eloquence of which Dr. Sircar alone was capable, elicited much discussion and spread his views to a great extent in the city. Referring to this publication, the STATESMAN of that day wrote:—

"We do not believe that we use the language of exaggeration, but the simplest language to describe a notable fact when we say that a new era dawned on this country when Dr. Sircar published and resolved to act upon his conviction, that the only method by which the people of India can be essentially improved, by which the Hindu mind can be developed to its full proportions, is by

the cultivation of the physical sciences. He saw that this was the only method by which the defects inherent in, and acquired of, the Hindu mind could be overcome. The despotism of a religion, debasing in all its present phases and of time-honoured customs, which, whatever their original philosophy, have become mischievous in the extreme, can only be shaken to its foundations by the irresistible force of recoil which the mind will acquire, when fed on the substantial nourishment of pure truths as presented by the handiworks of God."

The immediate result of the publication of the article was the adoption of an alternative Science course for the B.A. Degree Examination of the University of Calcutta.

DR. SIRCAR, THE GREAT ORGANIZER

The project of the Association was published to the world in December, 1869. It was followed, as Kristo Das Pal put it, by a most vigorous agitation, cogitation, and education of the mind. The organizing ability of Dr. Sircar became evident from the fact that he had been able to enlist the sympathy and co-operation of not only all sections of the public but also of the alien bureaucracy. No doubt it was a very happy moment, that a man of wide sympathies, deep culture and high education, Sir Richard Temple, happened to be the Lieutenant-Governor of Bengal. In his efforts, Dr. Sircar was associated with Prof.

Lafont, the Astronomer and Scientist of St. Xavier's College. Dr. Sircar had a complete insight into human nature. He was well aware that official support was the only key to unloose the purse-strings of his wealthy countrymen. The greatness of the cause, the nobility of the enterprise and the immensities of public utility that would result therefrom were no doubt sufficient inducement to the educated and enlightened middle class. But the merchant princes and landed aristocrats, hungry for title and fame, would slavishly follow the foot-prints of the official head of the province. Dr. Sircar was right. After six years of restless propaganda, with the full support of the Government, he was able to see the inauguration of the Science Association under the auspices of the then Lieutenant-Governor of Bengal on Saturday the 15th of January, 1876. That day should ever remain memorable in the history of India. It was a day of a great agreeable surprise to Dr. Sircar. He says:—

“Who could have realised even in dream that at the call of an obscure practitioner of medicine, the enlightened and the wealthy of the land, orthodox and heterodox,

old and young, nay, the princes of other lands having apparently no interest and no concern in the affairs of Bengal and the Bengalees, would come forward so promptly, so nobly and so liberally, to assist in laying the foundation of an institution, but vaguely understood to be calculated, in some future time, to elevate the physical and intellectual and, thereby, the social and moral condition of the natives of India."

It has already been said that pure lovers of the sciences belong to the first class of workers. Sircar was not a research scholar. He is not credited with any original discovery. He is also not known to have made any attempt at original research. He did not belong to the category of Platonists in the field of science. He was interested in science because he saw that it was the most powerful instrument of modern civilization. This interest in science was not motiveless. He loved science because it gave him control of natural forces. It unravelled to him the possibilities of immense power. It showed him the ways of harnessing her to his own advantage. It gave into his hands the magic wand which would dissipate the barriers with which nature has enveloped frail humanity. He looked with 'green eyes' at the wonderful progress of civilization in the Western countries. His speeches are full of

references to the achievements of Japan. That Asiatic country, which could not boast of any rich heritage from the past, like ourselves, realized that science was the only means of self-preservation. This realization helped her to keep pace with the progress of Western countries. Thus she has not fallen a victim to the onslaught of Western power. She has been able to deal with them on terms of perfect equality. I cannot better describe Dr. Sircar's object than in the words of his venerable colleague, the very Rev. Father Lafont :

"Dr. Sircar, seeing that the superiority of the Western nations was mainly due to their knowledge of science, wanted to diffuse that knowledge among his countrymen, in the hope that after mastering what had already been discovered by the Europeans, the Hindus might, in the course of time, add their own discoveries to those of their fellow brethren in the West. This project no one could deny was a noble and patriotic move towards the real welfare of the nation."

Thus there can be no greater folly than to expect some research every day from your scholars. It takes years to arrive at tangible researches. Referring to the time taken in the discovery of the spectroscope, Dr. Sircar said :

"Gentlemen, in this instance, you see how slow has been the progress of the discovery: It took a century and a

quarter from Newton to Wollaston and a quarter of a century from Wollaston to Sir J. Herschel and Fox Talbot, and a quarter of a century more from Herschel and Talbot to Swan and Bunsen and Kirchhoff, to complete the discovery, not to mention the laborious and expensive character of the researches that had to be made."

Thus we see that Dr. Sircar was not indulging in any fanciful, metaphysical, and un-practical propositions. He was a cold cause-and-effect reasoner. Thus his position in the field of science was that of an interpreter of the discoveries of the West to the students of the East and especially to the students of India. He was the High Priest in the Temple of Science.

We cannot pass over this stage of Dr. Sircar's life without telling the reader that he was a born teacher. It is only necessary to read one of the lectures he delivered to his students at the Science Association to understand this point. He delivered his first lecture when the Association was first inaugurated. The audience consisted of some of the most distinguished people of the city. The Lieutenant-Governor, Sir Richard Temple, was the President. Indeed as it was said, Dr. Sircar was best fitted to be the head of a

Training School of Science. Indeed, he was an excellent teacher and a very successful experimenter. He was invited by Lord Lytton, the then Viceroy, to the Government House, to reproduce his experimental lecture on Crookes's Tubes and Radiometers. In its initial stages, the Science Association was not expected to be anything more than a Training School. It was hoped that it would help in the diffusion of scientific knowledge. It was expected to prepare a band of teachers who would go forth into the world as Missionaries of scientific truths. It would teach only the ascertained principles. Dr. Sircar was the organiser, founder, and honorary secretary of such an institution. In this connection, it is impossible not to deal with the wonderful efforts of Dr. Sircar, to convince his countrymen that they were not, by nature and temperament, unfitted for scientific pursuits. He held out to them the ideals of Germany, England and Japan. He reminded them of the glory of their past. He recalled to their minds the achievements of their own ancestors in the realms of speculative philosophy. It was.

strange that the inheritors of such a civilization should look upon themselves as unfit for the appreciation of the revolution of science and engage themselves in researches leading to such revolutions. He did not like that his countrymen should remain idle spectators and be simply charmed by the wonderful exhibitions of Science. He was ashamed that they should remain the unproductive recipients of its practical achievements. He was extremely anxious that his own countrymen should take an active part in the progressive movements of the world. He wanted to see that day when his own people would help the onward march of humanity. In a most eloquent speech, he says :

"For a variety of reasons, the natives of India have long ceased to take an active part in the world of intellect. In this respect we are as if we are not. The vast tract of country which we inhabit is a perfect blank. Is this state of things to continue? Are the natives of India unfit or incapable by virtue of their organization to enter on the severer duties of life? Do the Indian youth really look upon scientific experiments in the same light as they do the feats of a juggler and the magician, mysterious, incomprehensible because referable to no definite laws, but the will of the performer? I say, Gentlemen, no! I would emphatically say that the Indian youth have shown as much aptitude for, and love of, science, as the youth of any country in the world. This has been the testimony which our professors and teachers

have heartily borne, and as you know them well, it would be useless for me to quote their very words. I would say, as I can say on the authority of personal experience, the Indian youth have an aptitude for, and love of, science, almost peculiar to themselves, an aptitude and a love nowhere else to be met with."

Thus his service to science was that he had awakened in India, a taste and an interest in its study. He had established an institution with facilities for such study. He had created opportunities for those who wanted to devote their whole lives to the study of science. He had arranged for lectures to be regularly given, in order to disseminate scientific knowledge. Thus he had prepared the ground for the growth of original ideas. He was the parent of scientific education in India.

THE INDIAN ASSOCIATION FOR THE
CULTIVATION OF SCIENCE.

The ideal which Dr. Sircar placed before himself was the establishment of an institution like the British Association of Sir David Brewster. In order to work up his idea, he wanted *freedom* for his institution. He wanted freedom from the officious interference of the Government. He wanted it to be entirely under our own management and

control. He insisted that there should be full scope for unbounded liberty of thought and judgment. The institution should be solely native and national. This was the ideal which he set himself to achieve. But in the initial stages it was not possible nor even desirable to restrict the teaching work only to Indian Professors and Lecturers. It was indeed the age which marked the beginnings of scientific education in India. It was a time when the average Indian, nay even the average student, looked with astonishment at a piece of magnet or loadstone. Scientific enquiry was in its infant stage. It was confined to the Medical College. It did not extend in any appreciable degree to academic institutions even like the Presidency College. Such was the time when the Science-Association was founded. Indeed, it was one of the fundamental objects of the founders that it should be solely under Indian management and control. There was one great difficulty. Was it possible to have Indian Professors to lecture at the institution? As has already been said, there were very few Indians at

that time who could pretend to have any knowledge of the Physical Sciences. Then again, even those who knew a little, were not at all expected to be good teachers. One may know many things. It is a different talent to be able to let others know what you yourself know. A great prodigy is not always a good teacher. So after a full consideration of all sides of this question, Dr. Sircar decided that the article of Indian management should not be made to apply to the teaching department of the Association. Patriotism and nationality ought not to interfere when we consider the universe of knowledge. The greatest writers and thinkers of the world do not belong to any particular climate or country. They are not the property of a single nation. They are indeed the heritage of the whole mankind. Sir Asutosh Mukerjea said that the principle of nationality ought to be deprecated in matters of higher learning and research. He held that truly Indians were not yet in a position to be more exclusive and chauvinistic than the nation of the West. He held up the example of Germany, which

though so rich in native talent, freely engaged the services of learned men to answer the needs of scholarship and research. What was Dr. Sircar's view about this same proposition? His patriotic friends had distinctly told him that the professorships should go to Indians only. He was accused of departing from the quintessence of his scheme when he invited the co-operation of European gentlemen in the work of the Association. But his answer was that his own countrymen had yet to learn even the rudiments of scientific knowledge. Hence in the interest of the progress of the natives, it was foolish to refuse the assistance of European experts, and specialists like the Rev. Father Lafont. Thus in a very politic way, without wounding the tender susceptibilities of his patriotic friends, Dr. Sircar succeeded in enlisting the sympathy and co-operation of all classes of people for the success of his scheme. The institution was to be a place of original research in all departments of science, and not an academy where the practical application of ascertained principles was taught. The object of Dr. Sircar was not to establish a

technical seminary and thus make his countrymen a nation of artisans and mechanics, but to diffuse among them the ascertained principles of Western Science in the hope that after mastering what had already been discovered by the Europeans, the Hindus might, in course of time, add their own discoveries to those of their fellow brethren of the West. The institution had one more object when it was established. It was the first of its kind. Even its foundation had to be preceded by a long period of preparation. It took six long years to educate the public mind to a necessity of such an institution. Dr. Sircar saw around him not even a few who were familiar with elementary principles of scientific study. So he thought his first duty was to send out of the Association, professors of science, well-equipped and trained, who would be welcomed in any college as the best interpreters of scientific principles. It is not possible in such a brief sketch like this, to give an account of the troubled career which this Association had, and the remarkable sacrifices which Dr. Sircar had to make in order

to enable it to live and grow into what it now is. But we cannot overlook two names which should ever remain dear to students of science in Bengal, nay in the whole of India. These two names divide between themselves the sole honour of providing the Science Association with its elementary necessities. Scarcely had the institution justified its existence when Kally Kissan Tagore came forward with a munificent donation of Rs. 25,000 for the scientific instruments and apparatus alone. He had also donated Rs. 5000 to the general, and Rs. 2500 to the building, fund of the institution. This had enabled the lecturers to place before the audience the latest discoveries of the Western scientists. A laboratory building was the next prime necessity. The Maharajah of Vizianagram came forward unsolicited, and undertook to bear the entire cost of the construction. Says Dr. Sircar, referring to the generous and patriotic assistance of that native prince from Madras,

"Thanks to the enlightened and princely munificence for which we owe a debt immense of the deepest gratitude, we have now a structure which is the largest building of its kind in the metropolis and which, fully

equipped, will serve the purposes of a physical and chemical laboratory, for a long time".

THE GREAT CONTROVERSY

Just about the time of the founding of the Science Association, a group of enlightened gentlemen in Calcutta awoke one morning and found that India was entirely dependent upon other countries for many of her luxuries as well as necessities. It was thought that a lame or a blind man was not more dependent upon his friends or servants than the Indians upon the foreign manufacturers. It is felt as a standing reproach to the inheritors of a great civilization. So this circle of patriots, who could count among them some of the biggest names in the metropolis, deemed that the greatest need of the country was not science speculation but science application. In their opinion the speculative sciences and the glorious literature of Western countries were very good things for those who were rich and, having abundance at home, had no anxiety to provide for the morrow. They were useless to those who had to make ceaseless efforts to keep body and soul

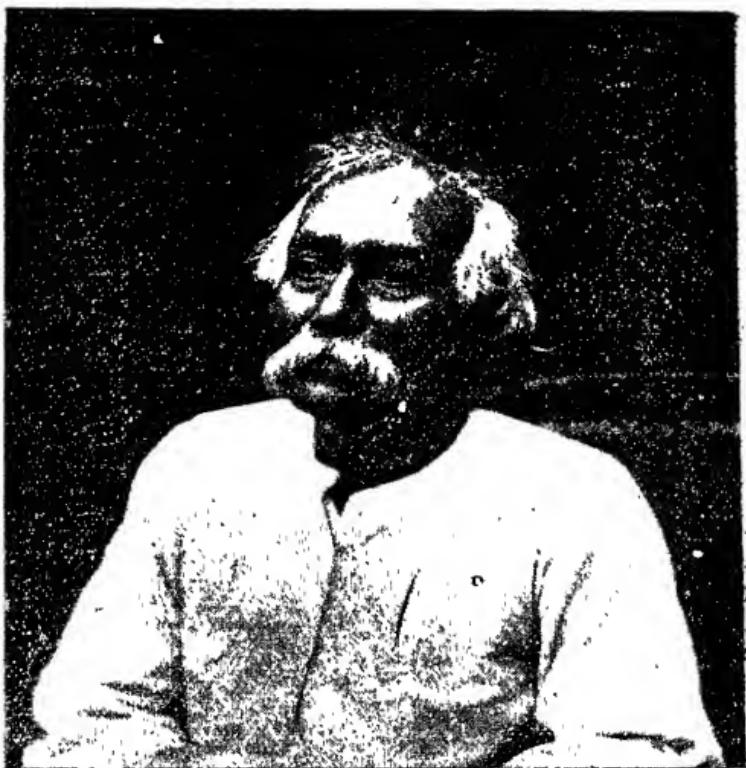
together. It was deemed a mischievous diversion of native energy to wrong channels. Dr. Sircar's scheme of a Science Association appeared to them but a vague and metaphysical speculation. It was not the need of the hour. It was an imposition on the country. The country did not want such an institution. It might require it after fifty years. It was a useless waste of public money. Our wealthy villages and ancient towns presented a most desolate spectacle. High families were begging from door to door. So these enthusiasts argued, the most crying need of the country was the establishment of a college to impart scientific and mechanical education to the youths of India. They took full advantage of the long but thorough preparation made by Dr. Sircar. They fixed, indeed, upon the most psychological moment for the inauguration of their institution. They wanted to commemorate the visit of the Prince of Wales to India, by founding an institution which would purge the country of all its manifold sufferings. They enlisted the sympathy and co-operation of Sir Richard Temple, the then Lieutenant-Govern-

or of Bengal.' They had started upon an active propaganda, which caused a Vesuvian outburst of criticism and condemnation of Dr. Sircar's Association. Malicious innuendos began to appear in public print. Sulphurous humour was the invariable characteristic of all references to the CALCUTTA HOMŒOPATHIST. The Indian League, which consisted of "earnest and well-meaning men who could pay sixteen annas to the rupee," had suddenly sprung into the forefront. Meetings were organised under the presidency of Sir Richard Temple and other great and distinguished personalities. It was advertised that within five days, over a lakh and forty thousand rupees were subscribed. All the local journals and publicists of any standing said with one voice, "This is business, indeed."

There is much truth in the Greek adage that an enemy in the disguise of a friend is most to be feared. Such were the members of the Indian League. When they found that Dr. Sircar commanded almost the veneration of the great intellectuals of the metropolis, they advertised that the object was not different from

that of the Indian Science Association. When they say that the great Astronomer and Natural Philosopher, Father Lafont, would not countenance a rival association to Dr. Sircar's, they proclaimed themselves as friends and helpers of the great Doctor. They even invited Dr. Sircar to arrange for a union of the two institutions. They said that theory and practice were but the dual aspect of the same enterprise. The aims and objects of both were essentially the same. They both sought the regeneration of our poverty-stricken country. Theory or a knowledge of elementary principles was indispensable prerequisite to all practical enterprises. Practice was in its own terms a useful process for the perfection of the theory. Thus it was fitting that they should amalgamate into each other and carry on the great work of Indian regeneration with redoubled efforts and augmented finances. Great names were introduced almost to coerce Dr. Sircar into submission. The great Doctor was not to fight his first battles. He was a veteran soldier. His courage had not forsaken him. He stood his ground and fought

his enemies. It is now necessary to explain Dr. Sircar's position clearly. He was the first, in this country, to familiarize the idea of scientific education. He had ploughed the field and prepared the ground. Just at that time, the Indian Leaguers placed before the public their attractive proposition of adding to the wealth of India by the cultivation of the practical sciences. They did not consult Dr. Sircar about their proposal. They did not feel bound to invite him to their meeting, they had not the common courtesy of asking for the co-operation of the greatest apostle of scientific education in this country. Their meetings, indeed, had the appearance of secret conclaves of interested persons to rob the Doctor of the fruits of his life-long labours. They had not placed before the public any detailed scheme of their work. They had been trading on that attractive catch-word, "Practical". Certainly, Dr. Sircar, as the organizer and founder of the Indian Association for the cultivation of science, could not be expected to join hands with such "irresponsibles". He was invited by Sir Richard Temple to



DR. MAHENDRALAL SIRCAR.

explain his position at a Conference of the two-parties. Dr. Sircar said that it was not his contemplation to found a *college* where students could obtain tuition for a certain term. His ambition was to establish an institution where students, after passing their state of pupilage, might have opportunities and means to prosecute life-long, or as long as they liked, some one or more branches of science. He had aimed at creating facilities for original researches in order to arrive at fresh discoveries. School-pupils could never be expected to rise to the manhood of original investigators of science. Referring to the proposed amalgamation, Dr. Sircar said that his scheme was no more than pure science-learning and science-teaching. He could not arrange in his scheme for any practical training in arts and mechanics. He took of science a higher and nobler view than the narrow, utilitarian and Benthamite one which seemed to animate the Leaguers. His object was not to drill men in the arts which constitute the manual and the mechanical industries. Thus, to his mind, the aims of

the two Associations were distinct and, on close examination, antagonistic. He held clearly that there could be no talk of amalgamation. He ended his eloquent speech with the pregnant remark that it was idle to waste time in conjectures and that the world was wide enough for both if they could work quietly and in peace. This controversy had revealed one of the greatest traits in the character of Dr. Sircar. He was most uncompromising in his convictions and policy. Indeed, this is the greatest lesson that rings out from every chapter of his life. Compromise is death. Compromise annihilates individuality, and then, what is there to survive? The Indian League dragged on a weary existence for a decade, and having done nothing that it had promised, ceased to exist. The Science Association with its modest beginnings has developed into a most potent centre of scientific research so that, as Dr. C. V. Raman has said, "a stream of new knowledge has flowed to every part of the world. It is now known wherever physical science is studied."

HONOURS AND DISTINCTIONS

In the fitness of things, Dr. Sircar's efforts did not fail to bring him public honours and distinctions. He had extorted the recognition of a reluctant Government. He won the unique distinction of being the greatest promoter of scientific enquiry in this country. Lord Curzon conferred upon him the honorary degree of Doctor of Law. He had already become sovereign in the realm of Homœopathy. His efforts for the prevention of disease, and his wide charities to the suffering in the city had endeared him to the citizens of Calcutta. He was elected a municipal councillor. He was appointed as an Honorary Presidency Magistrate, and a few years after, was made a C.I.E. His great sincerity and wide acquaintance with the varied needs of the province was recognized by the Government when he was nominated as a member of the Bengal Council. He had taken a very active part in the administration of the Calcutta University, as a member of the Syndicate and as the President of the Faculty of Arts. The Council of the Asiatic Society of Bengal was

proud to own him as one of its prominent members. He was a trustee of the Indian Museum and a life-member of the British Association for the Advancement of Science. Thus he was connected with every enlightened body in India and with many outside, either directly or indirectly. He had culled out his lessons for his countrymen from every progressive movement of the world. In the words of the late Raja Peary Mohan Mookerjee, Dr. Sircar lived to see the dream of his youth realised. At the time of his birth, his country was a silent, passive spectator of the achievements of Western Nations. At the time of his demise, India was an active participant in all the progressive movements of the world.

THE PASSING AWAY

Dr. Sircar had already reached the evening of his life. Though his unflagging zeal for the regeneration of India had made him capable of Herculean toil, yet it was clearly evident to every observer that Dr. Sircar had not long to live. The furrows of time were easily visible on his face. Though he had a stentorian voice,

his lungs began to feel the strain of his long speeches. He seemed to have beheld a ray of the Divine in his own heart. He had an attack of influenza in 1891. It was the first time that that fell disease visited this country. Soon after, he suffered from malaria and asthma. He had a presentiment that he would die of malaria. This did not make him less attentive to his malaria patients. No doubt, the fear of contagion haunted him throughout his life. But even "malaria lost its dread when compassion knocked at the wide portals of his heart". One of his patients was a poor and helpless boy in Hooghly. The daily fee for out-stations was Rs. 100. He attended for nine days and came back without any fee, but an attack of malaria. The second visit of this much-feared complaint was occasioned by his efforts to treat a patient at Punduah. This lasted for three years. He was slowly sickening into the grave. He was not able to digest his food. He was compelled to reduce his dietary considerably. The final stroke of Providence came in the cold November of 1896 when he was called upon to treat

Prince Ferokh Shah. He was unwilling to undertake the treatment. The insistence of a friend proved the greatest persuasion. The reluctant physician was taken to the residence of the Prince at Ballygunj. The place was deadly malarious. The Doctor caught the infection. He never recovered from the grip of that dangerous disease. The rest of his life was only a prolonged death. He could not be said to have lived. He did not enjoy even a single day of perfect health, ever after. But day after day, month after month, and year after year, he continued to deliver his precious lectures at the Science Association. All his later speeches contained the same prefatory remarks. At the beginning of every speech, he pleaded inability on account of sickness. At the call of duty to nurse his *pet child*, he rose willingly from his sick-bed, to bear any arduous toil. One day, he was about to start for the Association Hall, to deliver his usual lecture to the students. The time advertised was 4 P. M. At about 3 in the afternoon, a professional call came to him. A handsome fee of Rs. 200 was offered. But Dr. Sircar refused the

case, as it was very likely to engage him for a couple of hours. He would disappoint his anxious students. That should not be. Nothing should be allowed to interfere with his duty to the Association. He looked upon it as his greatest achievement. Under a most wasting disease, the great old man became thin, and lean and weak. He was seventy years old in 1903. A birth-day ceremony was organized by his loving son. Dr. Sircar felt that he was not to live even a twelve-month. But there was peace in his soul. He did not let his talents lie idle in him. He had used them to the best of his powers to glorify the Giver of all Gifts. There was great sorrow all around. The country was soon to lose a great man. He called all his near and dear relations and friends to his bed-side. He called on them to believe in God and religion. This was rather a novel thing from a cold dry-as-dust scientist. "No", he said : "Believe in God and Religion." He called on them to realize that the religion of God was in the soul of man. He was indeed religious. He had great faith in God and in His Omnipotence. He wanted religion but not

religiosity. He was a religious man but not a religionist. The last days of his life were indeed agonizing. But with a force of will, so characteristic of his early days, he recalled his mind from the terrestrial and the physical to concentrate it on the glory of God and the Majesty of the Creation. He bore his pains heroically. His last words were that every rational creature ought to thank the Creator every moment of his life for the continuance of his existence which he owes to Him and Him alone. Culture seemed widowed for the moment and a talented journalist of the day mourned the loss, in the words of Antony,

"Here was a Cæsar! when comes such another?"

SIR J. C. BOSE

PARENTAGE

JAGADISH Chander was born on Nov. 30, 1858, of an ancient and respectable family of Bikrampur, a village in Dacca, the Muslim capital of Bengal. From a very early age, Jagadish showed a marked bent towards inventions. His father, Bhagwan Chander Bose, who was a Sub-divisional Officer at Faridpur, gave a careful nursing to this inclination of his son. Bhagwan Chander was a man of strong character and considerable originality. His son has given some interesting portraits of him. He observes:—

He established industrial and technical schools, and it was then that the inventive bent of my mind received its first impetus. I remember the deep impression made on my mind by the form of worship rendered by the artisans to Viswakarma, God in his aspect as the Great Artificer; His hand it was that was moulding the whole creation; and it seemed that we were the instruments in His hand, through whom He intended to fashion some great design.

Bhagwan Babu trained his son with great care and gave him the education which he

thought best. When the present system of education was yet in its infancy, people used to be undecided whether to accept the new methods or follow the older ways of instruction in pathasalas. The first impetus of Western education impressed itself on some in a dead monotony of imitation of things Western, while in others it awakened all that was greatest in the national memory. To this latter category belonged the illustrious father of Sir Jagadish Chander. He, accordingly, sent his son not to an English school, but to a village pathasala to study with the common folk of the soil.

"In educational matters," says Dr. Bose, "my father had very definite ideas which are now becoming more fully appreciated. English schools were at that time regarded as the only efficient medium for instruction. While my father's subordinates sent their children to the English schools intended for gentle folk, I was sent to the vernacular school where my comrades were hardy sons of toilers and of others who, it is now the fashion to regard, were belonging to the depressed classes. From those who tilled the ground and made the land blossom with green verdure and ripening corn, from the sons of fisherfolk, who told stories of the strange creatures that frequented the unknown depths of mighty rivers and stagnant pools, I first derived the lesson of that which constitutes true manhood. From them, too, I drew my love of nature."

A vivid and touching picture of his mother then follows :—

When I came home accompanied by my comrades, I found my mother waiting for us. She was an orthodox Hindu, yet the 'untouchableness' of some of my school-fellows did not produce any misgivings in her. She welcomed and fed all these as her own children; for it is only true of the mother heart to go out and enfold in her protecting care all those who needed succour and a mother's affection.

EARLY EDUCATION

Dr. Bose was sent only to an old-fashioned village pathasala. He bears testimony to its value in these words: 'I now realise,' says Sir J. C. Bose, 'the object of my being sent at the most plastic period of my life to the vernacular school, where I was to learn my own language, to think my own thoughts and to receive the heritage of our national culture through the medium of our own literature. I was thus to consider myself one with the people and never to place myself in an equivocal position of assumed superiority'.

The person, to whose sole charge the boy was confided by his father, was not an up-country durwan, as is the custom with the well-to-do men of Bengal, but surprisingly enough, a lawless dacoit. This dacoit has a special history of his own. When Bhagwan-

Babu was the Sub-divisional Officer at Faridpur, the district offered a stronghold to a body of desperate dacoits. Once he arrested one of the great leaders of these dacoits, single-handed, without any sort of help from outside. The dacoit was subsequently sentenced to a long term of imprisonment. Strangely enough, when he was released, he came to Bhagwan Babu and sought for a new occupation as it was then simply impossible for him to revert to his particular vocation.

"My father took the unusual course," says Dr. Bose, "to employ him as my special attendant to carry me, a child of four, on his back to the distant village school. No nurse could be tenderer than this ex-leader of lawless men, whose profession had been to deal out wounds and deaths. He had accepted a life of peace, but he could not altogether wipe out his old memories. He used to fill my infant mind with the stories of his bold adventures, the numerous fights in which he had taken part, the death of his companions and his hair-breadth escapes. Numerous were the decorations he bore."

Though this lawless leader of fierce dacoits had not an inch of respect for the laws of the country, yet he possessed a deep and high veneration for the moral laws. He never abused the great trust placed upon him. "The trust imposed on this marauder," observes Dr. Bose, "proved to be not altogether ill-placed, for, once in a river journey, we were pursued by several long boats which came too near for us to effect an escape, and the erstwhile dacoit leader, my attendant, stood up and gave a peculiar cry, which was evidently understood. For the pursuing boats vanished at the signal."

STUDY IN ENGLAND

Mr. Bose watched his son's educational progress with keen interest. • When Jagadish graduated himself from St. Xavier's College, Calcutta, he had a strong desire to go over to England and read for the Civil Service Examination. This was the tempting path lying wide open to him. He sought the approval of his father for his ambitious scheme. But Bhagawan Chunder would not allow him to do so. Though an able and

just administrator himself, he had no intention of sending up his son for that kind of work. He foresaw like a prophet the great possibilities lying in the womb for the future. He wished him, therefore to be a scholar—of what fame, he left to the future to unfold.

“When, later, I wished to go to Europe,” says Sir J. C. Bose, “and to compete for the Indian Civil Service, his refusal as regards that particular career was absolute. I was to rule nobody but myself. I was to be a scholar not an administrator.”

But the elder Bose had no objection to his son pursuing a medical or scientific vocation. Accordingly, he left for England. Of his studies in the English Universities, his biographer, Patrick Geddes, writes as follows:—

Arrived at London, his B.A. diploma served him for matriculation, and he started the usual first-year work of the medical student. The Physics and Chemistry were much what he had done before, but the Zoology course, under Ray Lankester, was interesting and wholly new; for even to this day, Calcutta University excludes zoological science. Botany too, in the summer term, was congenial, so that the preliminary scientific examination was passed without difficulty. With the following autumn term began the first year of medical studies proper, with anatomy. But the fever was still as bad as ever, with even more frequent attacks, which were brought on intensely by the odours of the dissecting room. Hence the anatomist

advised young Bose to give up his medical course as hopeless. Dr. Ringer, then the most distinguished physician of the Hospital, as well as one of the best and kindest of professors, who had already been treating him with arsenical and other injections, but all without success, concurred in this advice. Thus thrown into new perplexity, Bose decided on leaving London and taking to science at Cambridge.

He passed his B. A. examination in 1884 from Christ College where he won the Natural Science Scholarship. Next year, he secured the B. Sc. Degree from the London University.

RETURNS TO INDIA

But more than his studies was the inspiration he received from the leading lights in the world of science. In that excellent account of "The Life and Work of Sir Jagadish Bose" (Longmans Green & Co), Prof. Patrick Geddes, the enthusiastic biographer, very rightly asks :—

What better teacher could he have had for Physiology than Michael Foster, or for Embryology than Francis Balfour, then at the very height of his brilliant powers ? Geology too had its interest, both from Professor Hughes and his kindly and hospitable wife; and so on. But after the middle of the second year, he settled down to regular work in Physics, Chemistry and Botany. Of Professor Liveing's chemical course, the stimulus to spectroscopy is specially remembered. Vines' lectures and laboratory of Botany were also much appreciated, and Francis Darwin's first course of Vegetable Physiology was given before he left. And most educative and

decisive for the future physicist was the teaching of Lord Rayleigh, whose admirably patient and careful experimentation, to the most scrupulous accuracy, with every fact or of disturbance allowed for or compensated, and all with correspondingly clear and careful explanation, produced a profound impression, which has been lifelong.

After completing his education abroad, he returned to Calcutta. Who could have dreamt that Jagadish would again go over to the land of his education to preach a startling and original theory? Who could have imagined that Jagadish would one day assume the position of a teacher in the land, where he earnestly sought for light, the light of science?

Bose, now twenty-five, got an introduction from Prof. Fawcett, the Economist, to Lord Ripon, the then Viceroy of India.

• HIS LABOUR IN THE CAUSE OF SCIENCE.

Though Dr. Bose got the Professorship of Physics in the Presidency College, after some difficulties, he could not obtain any facilities to carry on his researches.

And he was also the victim of race discrimination in the Department. When Bose joined service, an Indian Professor's income, even if he be in the Imperial service, was two-thirds that of a European. A further insult was



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offered him too by cutting down half of even this two-thirds since his appointment was only officiating. But Bose was determined and strong.

With this combination of personal pride with loyalty to his countrymen and colleagues, he decided on a new form of protest, and maintained it with unprecedented definiteness and pertinacity. As his protest was disregarded, he resolved never to touch the cheque received by him monthly as his pay, and continued this for three years, with what privations accordingly need not now be entered into, save with a word of appreciation for his wife's brave acceptance of them.

After three years' work, both the Principal and the Director of Public Instruction came to realise the value of Bose's work and his character, and became his staunchest friends.

In consequence of this change of view of the Director, Bose's appointment, by help of a special order from the Government, was not only made permanent, but this with retrospective effect. He therefore received his full pay for the last three years in a lump sum.

"When I first came," Sir Jagadish said, "there was no laboratory worth the name in the Presidency College. I had to work in my private laboratory." Yet the new professor never lost heart. The watchword of his, nay, of every great scientist, has been patience. And patience did beget good results. For, "ten years later," we are told, "a provision

was made for a small laboratory. That was a blessing in disguise for me."

He began writing a series of scientific articles as early as 1895. His first contribution was on "The Polarisation of Electric Ray by a Crystal." It was published in the JOURNAL OF THE ASIATIC SOCIETY OF BENGAL, in May, 1895.

Then followed two articles about Electricity which were published in the ELECTRICIAN, the leading electrical journal, in the same year.

Now came the turning point in his scientific career, and that was the result of his essay on the "*Determination of the Indices of Electric Refraction.*" The Royal Society at once appreciated the highly scientific value of the research. It was then considered a high honour to a scientist to have his essay published by the Royal Society in its journal. They not only published the paper, but did great honour to the Indian scientist by offering him "a subsidy from the Parliamentary grant made to the Society for the

advancement of science." This was indeed a unique honour, and we have it from Prof. Bose himself that: "Two years after the Royal Society had offered a grant to me for the continuation of my work, the Government of Bengal came forward and offered me some facilities. No Government could afford to spend money on prospective geniuses."

One doubts whether the Bengal Government would have come forward to his help, had not the Royal Society offered him the grant.

All along, Dr. Bose has been an ardent student of science. To learn, to wait, was to him, the key to success. On an humble scale, he worked and worked and never looked forward for a reward. But soon the reward did come in the shape of an astonishing discovery. It was in the year 1895 that he sent the result of his research to the Royal Society which had lent such a helping hand to his noble cause. The learned Society was literally amazed at the important contribution made by him for the advancement of science. Then the University of London came forward to pay

homage to the great Indian *savant* and conferred on him the Degree of Doctor of Science.

A devoted apostle of science, Dr. Bose now turned his attention in another direction. The possibility of transmitting electric telegraphic signals through space without the use of wires, that run directly from the transmitting to the receiving instrument, engaged the attention of three master-minds of the world at one and the same time—Professor Marconi of Bologna University, a great scientist of America and Dr. Bose in India. This has not been the only occasion when great scientists of different places have been deeply engaged simultaneously in solving one of the greatest riddles. Now, these three men of science were driving hard at how to transmit electric telegraphic signals. And it was Dr. Bose who first clearly demonstrated it. So far back as 1895, at an experimental demonstration in the Calcutta Town Hall in the presence of the Governor, he transmitted ether wave through a solid wall and a line of men and made it displace a heavy weight,

ring a bell and explode a miniature mine placed in a closed room.

LECTURES BEFORE THE ROYAL INSTITUTION.

For a scientist, to be asked to deliver lectures on his own researches before the Royal Institution rendered famous by the works of Davey and Faraday, is a signal honour. But Dr. Bose was thrice asked to give discourses on his momentous discoveries.

It was in 1897 that he was first asked to deliver before the Royal Society the Friday evening discourse. He acquitted himself very creditably and spoke on electrical waves. He continued his experiments on plant and animal response to stimuli. So striking was the correspondence that, when Bose showed the records to Sir Michael Foster, the veteran physiologist picked up one and said:

‘Come now, Bose, what is the novelty in this curve? We have known it for at least the last half century.’ ‘What do you think is it?’ said Bose. ‘Why, a curve of muscle response, of course.’ ‘Pardon me; it is the response of metallic tin.’ ‘What!’ said Foster, jumping up—‘Tin! Did you say tin?’ On explanation, his wonder knew no bounds; and he hurried Bose to make a communication to the Royal Society, which he (then Secretary,) offered to communicate.

On May 10, 1901, he delivered his second Friday evening discourse before the same august body. He demonstrated this time fully and elaborately the identical nature of reactions in plant and animal.

The lecture was highly appreciated and its totally unexpected revelations created wide interest in scientific circles. But then troubles were brewing, to which we shall refer immediately.

After his preliminary communication, Bose read his paper at the Royal Society on June 6, with full and detailed experimental demonstration. The rest of the story will be told in Prof. Geddes' words :—

The paper seemed as well received as usual, but the blow was now to come; and this from no less than Sir John Burdon Sanderson, who was then, and for many years had been, 'the grand old man' of physiological science in England. His work, moreover, had largely lain not only in the study of the behaviour of muscle and nerve under stimulation, but very specially upon the movements of the Venus' fly-trap (*Dionaea*), to which Darwin had first called his attention, and to the electrical physiology of which he had devoted unsparing labours during many years. He thus stood out as a peculiar authority on the electro-physiology both of animals and plants so far as was then known; and his interest was still so keen that he had come up from Oxford for this paper. He was naturally the person to whom all looked to open the usual discussion after the paper. He began with a compliment on Bose's

previous physical work; but then said it was a great pity that he should leave his own sphere of study, in which he had attained such acknowledged distinction, for other fields which properly belonged to the physiologists. Professor Bose's paper was still under consideration for publication; but he might give him the advice that the title should be changed from 'The Electric Response' to 'Certain Physical Reactions,' so leaving to physiologists the use of their term 'Response,' with which physicists are not concerned; and further, as to the Electric response of ordinary plants described at the end of the paper, he would say that it was absolutely impossible, since he had tried to detect it for many years past, and never could obtain any. It simply could not be!

Two other professors supported Sanderson, and Bose, in his reply, held his ground and said that "it seemed inexplicable that the doctrine could be advocated—and in the Royal Society of all places—that knowledge should advance so far and no further; so he could, on no account, alter a word of the paper, even at the risk of refusal of publication, unless he were shown, on scientific grounds, wherein the experiments he had just shown were faulty or detective." This was too much for the learned academicians. The opposition was not based on scientific grounds.

As a physicist, he was regarded as an intruder in the domain of physiology. As his English biographer finely pointed out: "As an unsophisticated man from the East, he had

seriously taken the lessons preached by the West about the evils of the caste system ; but here he felt he had come against a yet worse system of caste whose etiquette he had unwittingly offended."

Thus prejudice and personal antipathy got the upper hand, and Dr. Bose's paper was shelved and a bald telegram blurted out: "Bose's Work and Paper are rejected by the Royal Society."

Bose, who had returned to India, now applied for an extension of the period of deputation in order that he might go again to England and justify his contentions. Thwarted in his attempts, he persisted till he got his own way. Heartened by the encouragement afforded by the Secretary of State who was struck by Bose's courage,

he went to work anew at the Royal Institution Laboratory. He at first feared cold reception, but was consoled by a brother physicist: 'You can't poach on other people's preserves without some resentment ; and you've upset their apple-cart.' He settled down to work for the vacation at his London home, and then returned to the Royal Institution when it re-opened in October. Work abated depression, but did not remove it. About this time he was cheered by a letter from Professor Vines, the well-known botanist and vegetable physiologist of Oxford, who expressed interest, asked to see his experiments'

and came accordingly to the Royal Institution Laboratory, bringing with him Horace Brown, another effective investigator of the process of plant-life, and Howes, who was Huxley's successor at South Kensington.

With the first application of stimulus to the plant, a wide wing of the galvanometer-mirror's light beam along the scale demonstrated its sensitiveness. Never before had Bose seen three sober Englishmen so joyously excited: 'they were just as mad as boys.' Said Howes: 'Huxley would have given years of his life to see that experiment.' Said another: 'What did you let off steam when you discovered this? You should shout, or you will kill yourself by repressing it.' Then in business mood: 'The Royal Society has not published your paper, so you can give it to the Linnean. We are its President and Secretary this year, so we invite you to read us a full paper. Show us your experiments; and we will invite all the physiologists and particularly, your opponents.'

But then new difficulties cropped up. It was alleged that his results were by no means new! They had already been discovered by some one else.

Results substantially similar to these obtained by Bose had been communicated to a London scientific society in November 1901 by the physiologist who had seen Bose's experiments before the Royal Society (June 1901) and had also taken part in the subsequent discussion. Bose learned of the new turn of affairs from a letter from Professor Howes, as the Secretary of the Linnean Society. A new period of depression followed, far deeper than the preceding one, but he rallied himself to reply, formally asking for an inquiry into the matter. This was at once granted. Vines and Howes, both also Fellows of the Royal Society, had fortunately seen proofs of Bose's paper there ten months before that at the Linnean, and five months before the other claimants' communication. Bose's lecture at the Royal Institution, a few days earlier than the Royal Society function

was also in print and in evidence. With all the facts before them, the committee of inquiry had no hesitation. Bose's right to absolute priority was completely established, and the paper was published accordingly.

It is useless to recount the story of his trials. Its lessons, however, should be borne in mind. That truth prevails in the end, that persistency wins and that even the Royal Society is not without its share of the vanity of learning !

He was invited again, in 1915, to deliver for the third time another Friday evening discourse. A well-known *Review* writing in 1914, said :—

The great honour of delivering Friday evening discourse before the Royal Institution of Great Britain has again been offered to Dr. J. C. Bose. The subject of Dr. Bose's discourse will be his recent psycho-physiological research, which, opening out a new line of research, has created much interest in the scientific world. Professor Bose has also been invited to deliver a course of lectures before the University of Oxford. That this is the third time that Professor Bose has been invited to lecture at the Royal Institution is a very rare distinction indeed. To this may be added that he has been invited by the Cambridge University, too, to deliver a course of lectures. If time permits he will fulfil his engagements to lecture before some learned societies in France and Germany, but it will not be possible, perhaps, to include America in his forthcoming tour.

The third appearance of Dr. Bose before the Royal Institution was part of an

extended tour to which we shall presently return.

LECTURES IN PARIS

It must be mentioned here that, in 1900, he was sent by Sir John Woodburn, the Lieutenant-Governor of Bengal, and the Government of India to represent this country at the Paris Congress of Science and he acquitted himself so well that, by universal consent, it was declared that he had shed lustre on the Government which chose him and the country he represented. A little later, he was invited to deliver a series of lectures at Paris on his new discoveries. The first lecture was given before the Societe de Phisique, the second at the Sorbonne, the third before the Societe de Zoologique. He was elected about the year 1902 to the Council of the Societe Francaise de Phisique.

HIS TOUR ROUND THE WORLD

We referred to Dr. Bose's third Friday evening discourse. He was also invited by the Oxford University to deliver a series of

lectures. His assistant, Mr. B. Sen, wrote of them :—

Dr. Bose gave his first lecture at Oxford on the 20th May. The most distinguished scientists were present. When they saw the experiments, they were convinced that "life is one." Before this, results of Dr. Bose's enquiry were so astonishing to them as to challenge their belief. Nothing short of actual visualisation could convince them. It was a great success. They all unanimously said that the significance of Dr. Bose's discoveries was far-reaching. Indeed, they do appreciate him now. As regards his instruments they simply marvel at their ingenuity. They all ask "where did you get them made;" and with real pride did Dr. Bose reply, "in India." To-morrow the President of the Royal Society is coming to this house to see some of his experiments.

In June, he addressed the Cambridge University. Both Prof. Seward who was in the chair and Sir Francis Darwin spoke in memorable terms of the completeness of the demonstrations provided by his instruments. Interest was so keen that the Botanical Department of Cambridge imported soil from India to give Dr. Bose's plants the most favourable conditions for exhibiting their specific reactions. Professors Starling, Oliver and Carreth Read were also deeply impressed with the demonstrations. Mr. Balfour paid his laboratory a long visit and was much struck with the significance of Dr. Bose's discoveries.

to psychologists. On the 27th June, Prof. Bose gave an address illustrated by experiments before a meeting of *savants* at Vienna. Prof. Molisch, the Director of the Pfargen Physiologishes of the Imperial University of Vienna, while proposing a vote of thanks, said that Europe was indebted to India for the method of investigation initiated by Dr. Bose. Some of the workers in plant physiology expressed a wish to be trained in his methods in Prof. Bose's Laboratory at Calcutta.

Prof. Bose visited America also during this tour. He was flooded with invitations from Maine to California. Learned bodies such as the New York Academy of Science, the Brooklyn Institute of Arts and of Sciences, the Harvard, the Columbia and the Chicago Universities listened with delight to him and presented him with addresses.

BACK TO INDIA

Dr. Bose returned home on the completion of his world tour. In reply to one of the numerous addresses of welcome which were presented to him, Dr. Bose observed:

This is the fourth occasion on which he has been deputed to the West by the Government of India on a scientific mission, and the success that has attended his visit to foreign countries has exceeded all his expectations. In Vienna, in Paris, in Oxford, Cambridge and London, in Harvard, Washington, Chicago and Columbia, in Tokyo and in many other places his work has uniformly been received with high appreciation. In spite of the fact that his researches called into question some of the existing theories, his results have notwithstanding received the fullest acceptance.

In these new investigations on the borderland between physics and physiology, they held that Europe has been left behind by India, to which country they would now have to come for inspiration. It has also been fully recognised that science will derive benefit when the synthetic intellectual methods of the East co-operate with the severe analytical methods of the West. These opinions have also been fully endorsed in other centres of learning and Dr. Bose had received applications from distinguished Universities in Europe and America for admission of foreign post-graduate scholars to be trained in his Laboratory in the new scientific methods that have been initiated in India.

Though a prophet is seldom respected in his own country, Bose received ample recognition in India. The University of Calcutta paid him due homage and conferred upon him the title of Doctor of Science.

The Punjab University also expressed its deep appreciation of his novel scientific discoveries by inviting him, in 1913, to deliver a course of three lectures illustrated with experiments. This was the first time that a Bengalee Professor was asked by the Univer-

sity of the land of the five rivers to deliver a course of scientific lectures to its students. [The second man, so honoured, was Dr. P. C. Ray, the founder of the Bengal School of Chemistry.] The Punjab University offered Dr. Bose a fee of Rs. 1,200. But Dr. Bose, with his natural generosity, made over the entire sum to the University to be given to a research scholar in monthly instalments of Rs. 100.

Dr. Bose opened his address by alluding to the historic journey of Jivaka, who afterwards became the physician of Buddha, making his way from Bengal to the University of Taxila in quest of knowledge. Twenty-five centuries had gone by, and there was before them another pilgrim who had journeyed the same distance to bring, as an offering, what he had gathered in the domain of knowledge. He called attention to the fact that knowledge was never the exclusive possession of any particular man, nor did it ever recognise geographical limitations. The whole world was interdependent, and a constant interchange of thought had been carried on throughout the

ages enriching the common heritage of mankind. Hellenic Greeks and Eastern Aryans had met here in Taxila to exchange the best each had to offer. After many centuries, the East and West had met once more and it would be the test of the real greatness of two civilizations that both should be finer and better for the shock of contact. The apparent dormancy of intellectual life in India had been only a temporary phase. Just like the osculation of the seasons round the globe, great pulsations of intellectual activity pass over the different peoples of the earth.

With the coming of the spring, the dormant life springs forth; similarly the life that India conserves, by inheritance, culture and temperament, was only latent and was again ready to spring forth into the blossom and fruit of knowledge. Although science was neither of the East, nor of the West, but international in its University, certain aspects of it gained richness of colour by reason of their place of origin. India, perhaps through its habit of synthesis, was apt to realise instinctively the idea of unity and to see in the-



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phenomenal world a universe instead of a multiverse. It was this tendency, the lecturer thought, which had led an Indian physicist, like himself, when studying the effect of force on matter, to find boundary lines vanishing, and to see points of contact emerge between the realms of the living and the non-living.

THE MASTER-DISCOVERY

Now, what is the discovery of Sir Jagadish Bose, which has created such a stir in the scientific world? It is that discovery which has conclusively proved that "there is no sharp dividing line between the nervous life of plants and animals, and in one respect, it seems that the life of the plant Mimosa exactly reproduces the life-history of human nations." Now, what was the prevailing theory with respect to plants in the scientific world? The universally accepted theory has been that, in plants like the Mimosa, there was no transmission of excitation analogous to the nervous transmission in the animal: the propagated effect being considered as a mere hydro-mechanical disturbance. This

theory was based on the experiments successfully carried out by the famous German plant-physiologists, Pleffer and Haberlapdt. On account of the eminent position held by the German scholars, the theory, propounded by Dr. Bose before the Royal Institution about fifteen years ago, received but little acknowledgement from the other plant-physiologists of the West.

The principal points of difference are aptly noted down by Dr. Bose himself in a paper, from which we cull the following :—

Few things appear to stand out in such striking contrast as the life activities in the animal and in the plant. Scientific inquirers have, indeed, been struck by the glaring differences between the two. Animals respond to a shock by movement, whereas most plants maintain under a succession of blows an attitude of passivity. Certain tissues of the animal go on beating incessantly without any apparent cause; this spontaneous activity undergoes very characteristic modifications under the specifications of different drugs. No corresponding phenomena had been suspected in the plant. Animal tissues give electric signs of irritation; ordinary plants, according to leading electro-physiologists, show no such signs of excitement. In the animal, again, there is an evolution of the wonderful nervous system, by which the organism is put into intimate communication with its different parts and with the environment. In the vegetal organism on the other hand, all authorities are unanimous in declaring that there is no such thing as a nervous impulse even in a plant admittedly so sensitive as *Mimosa Pudica*. The two streams of life, in plant and animal,

would thus appear to flow side by side, under the guidance of laws which are altogether different.

But Sir Jagadish Chander's investigation has upset the hitherto universally accepted theory, and has successfully demonstrated the identical nature of the nervous impulse in the plant and animal. The success of the new research is largely due to the invention of a new apparatus of extreme sensibility. It is so delicately constructed as to enable the plant to record automatically its perception of stimulus and the speed of its nervous impulse.

THE RESONANT RECORDER

This new apparatus, Sir Jagadish calls the Resonant Recorder.

The principle of my Resonant Recorder, says Dr. Bose, depends on a certain phenomenon, known in music as resonance or sympathetic vibration. It may be so tuned as to thrill to certain notes and not to others. An artificial ear can be constructed to resonate to a sound of a definite pitch. The drum of the artificial ear is made of thin soap-film; a beam of light reflected from its surface forms characteristic patterns of colour on a screen. To various cries this ear remains deaf, but the apathy disappears as soon as the note to which the ear is tuned is sounded at a distance. On account of sympathetic vibration, the artificial ear-film is thrown into wildest commotion and the hitherto quiescent colour pattern on the screen is now converted into a whirlpool of indescribably gorgeous colours of peacock green and molten gold.

In the same manner, if the strings of two different violins are exactly tuned, then a note sounded on one

will cause the other to vibrate in sympathy. We may likewise tune the vibrating writer with a reed. Suppose the reed and the writer had both been tuned to vibrate a hundred times in a second. When the reed is sounded, the writer will also begin to vibrate in sympathy. In consequence of this, the writer will no longer remain in continuous contact with the recording plate, but will deliver a succession of taps, a hundred times in a second.

With this apparatus, we get a record which consists of a series of dots, and the distance between one dot and the next represents one-hundredth part of a second. So extra-ordinarily delicate is this new instrument that, by its means, it is possible to record a time interval as short as the thousandth part of the duration of a single beat of the heart.

Sir Jagadish has these delicate instruments manufactured by Indian artisans under his direct personal supervision. Now, when his novel theories are being recognised and accepted by the celebrated scientific societies all over the world, orders are also pouring in for these purely Indian instruments.

The researches of Dr. Bose have brought to light many of the activities which we have been accustomed to associate only with

animal life. Suppose we give a blow to the plant, how long will it take to perceive the blow and give an answering signal? The time has been found to be six-hundredth part of a second. This period is subject to modification as in the animal under special conditions. Thus, under fatigue, the period is considerably prolonged; after a severe shock it is said to remain dazed for a long time. Moreover, in summer, the speed of nervous impulse has been found to be about 30 millimetres per second. But it may increase under warmth and decrease under cold.

Again, Dr. Bose has succeeded in arresting the nervous impulse of the plant by interposing an electric block, in a manner similar to the corresponding arrest in the animal nerve.

Intoxicating liquor produces the same effect in plants as in animals. When Dr. Bose poured out a little poison on the plant, the record showed an astonishing result. The speed of nervous impulse instantly decreased.

Professor Bose has also proved that the trees begin to sleep at 12 P. M. and get up at 8. A. M., in the morning, like the civilized

nations of the world. The illustration of the death of a plant and also the reversal of the stimulus at the time of death, was lucidly explained.

In establishing these facts with experiments, Dr. Bose had to criticise the prevailing opinions of the great German scholars and totally upset their theories. "Professor Bose strongly criticises," says a German scientific paper, "*Dutrochets*" theory that the transmission in plants is one of hydro-mechanical disturbance and not of true excitation. He urges that the capillary tubes will offer great resistance to the passage of water in case where feeble deformation of tissue had been caused by mechanical stimulation. Besides, excitation is induced and transmitted by means of stimulus which causes no mechanical disturbances. As regards *Pfeffer's* experiment of transmission through chloroformed regions, Bose explains that the penetration of narcotic inside the tissue was too slight to be effective."

Haberlandt, who scattered the tissue in all probability, failed to kill all the cells. Bose claims that transmission of excitation in the plant is analogous to the

nervous impulse in the animal. The inference of temperature and velocity supports his view.

THE EFFECT OF THIS DISCOVERY

Now, one may be tempted to ask:—"All these discoveries and researches are good, but what material good will it render unto the world? Will it put an end to the endless suffering of humanity?"

Let us first answer the question in the words of the great scientist, Faraday. Faraday had succeeded in making a wire carrying a current move when in a magnetic field, and the visitor said: "Tell me, Professor Faraday, and of what use is this new discovery," to which the reply was,—"Sir, of what use is the new-born child?"

Really, this discovery is in its infancy, who can foretell that great results may not come from it? When the law of gravitation was discovered, its author could not even imagine that it would be productive of such immense good. But also in the near future, the discovery "would mean an advance," in the words of Sir J. C. Bose, "of a revolutionary character in the science of Physiology, of

Medicine and of Agriculture." This opinion has been endorsed by the famous scientific journal *The Lancet*, which speaks highly of the biological importance of Professor Bose's discovery :—

The study of responsive reactions in plants must be regarded as of fundamental importance to the elucidation of various phenomena relating to the irritability of living tissues.

This discovery about the plants, which will, in the near future, throw an entirely new idea and light on agriculture, is not the only department which will, through centuries, perpetuate his lasting fame. From the beginning, he devoted himself heart and soul to discovering one broad and bold principle, and to the realisation of this noble object, he spared no pains and worked patiently on against powerful odds—both in Europe and America. It is "the existence of similarity of phenomena in various spheres of things living or dead on their molecular basis of matter."

PLANT RESPONSE

In his monumental work "Plant Response," published in the year 1906, he has recorded a series of wonderful discoveries which evoked

considerable enthusiasm and admiration in the scientific world. There we find him dealing with, and proving beyond any shade of doubt, these discoveries :—

His experiments on root pressure and the rise of sap; those by which he seeks to demonstrate that not only sensitive plants, but all plants respond to excitation by variation of turgescence and electrical state; his comparison of the glandular structures of the sun-dew and pitcher plants with animal glands; his demonstration of Dr. Waller's "blaze current" in a brominated lead plant and assertion that it cannot be regarded as a sign of life: his demonstration on the leaflets of biophytire of the anodic and kathodic effects of constant current, and the velocity of transmission of excitatory waves; his comparison retentiveness of molecular change in metals with memory.

Reviewing the above book and the book on "Electro-physiology" published in 1907, the well-known scientific paper, *Nature*, observed :—

A biologically equipped reader will experience dazzled admiration for the logical progressive way in which the author builds up, not in words, but actually on a complete functioning plant from three simple conceptions.

The paper went on to add:—

In fact, the whole book abounds in interesting matter skilfully woven together, and would be recommended as of great value, if it did not continually arouse our incredulity.

GOVERNMENT RECOGNITION

Bose was to have retired in 1913, on the completion of his fifty-fifth year; but the

Bengal Government, in recognition of his services to the Presidency College and of his great influence over students, extended his period of service for two years, so that he retired in November 1915. As a further acknowledgement, the Government gazetted him as Emeritus Professor on full pay instead of pension—a distinction so far unique in the Educational Service of India. Thus was secured his permanent connection with the Presidency College, whose renown he has so largely enhanced. Further than this, he received a Knighthood and the Companionship of the Star of India.

The Government of India were at first very slow in recognising Dr. Bose's services to the cause of science. It was only, after the Royal Society honoured him, that they began to help him in various little ways, and in 1900, sent him up to the Congress of Science in Paris. They conferred the distinction of C. I. E. in 1903, and at the time of the Coronation in 1911, they conferred on him the title of C.S.I. When Sir J. C. Bose returned in 1916 from America, the Govern-

ment of Bengal arranged for a Sheriff's meeting to offer him a welcome, and a Knighthood was confirmed on him. A huge meeting of students was held to offer Sir J. C. Bose their congratulations on the knighthood, and Dr. P. C. Ray appropriately occupied the chair. Among other things he remarked that Professor Bose must not be looked upon as a mere discoverer of scientific truth but as a Yuga-Pravartak, *i.e.*, as one who has brought about a new epoch in scientific thought and methods and synthesis. He referred to Dr. Bose as a great man and an unselfish scientist. He said that if he had gone on with his electrical researches, in the course of which he ably "succeeded in sending wireless messages, before Marconi had done so, and if he had taken out patents for the apparatus and instruments which he had invented, he could have made millions by their sale." But he was a scientist pure and simple, he himself toiled on and on in spite of ridicule, opposition and lack of any recognition, leaving others to make money by his researches.

THE BOSE RESEARCH INSTITUTE

The Bose Research Institute, which Dr. Bose has founded, will be a lasting monument of his greatness. Dr. Bose had felt from very early days the extreme difficulties due to the absence of well-equipped laboratories in India. He knew also how little research work was encouraged in our Universities. Writing in 1913 to the *Bengal Educational Review*, he made some noteworthy observations. He maintains in it that there is no necessary antagonism between teaching and research. "The object of a University being the advancement of knowledge, this must include the complementary functions of the discovery of truth and diffusion of knowledge. It may be said generally that teaching degenerates, unless it be kept in touch with research; since the constant repetition of second or third-hand knowledge leads to mere mimicry in pupils; the living touch of reality is lost." He proceeds to say that the status of a university depends on the answer to these questions: What advancement in any branch of knowledge has been made by you? What

discoveries and investigations have been brought about under your fostering care? Is your university to be always a preparatory school for the foreign universities which have a world status? Will you never be able to make your work so distinguished that, instead of there being a constant export of your students to other universities, there should be an interchange and that you should receive an import of foreign students attracted by the special contribution which your university has made to the general stock of knowledge? "This is not to be regarded," he adds, "as an unrealisable dream. It has been accomplished before. The fame of Nalanda and Taxila did attract students from other lands, who made long pilgrimages to the Indian shrines of learning."

Dr. Bose says in the same article that the facilities offered by the Government are not many and that they are on highly red-tape lines. Referring to the possibilities in India, he says of the Indian students:—

In my experience, there is a genuine desire among a fair number of students to undertake research work. But as regards success in such work, I think it is often

forgotten that research is different from class-teaching. There are at least ten thousand workers all over the world engaged in original investigation, and we hear of comparatively few successful results. You cannot command results by merely opening classes. There must be favourable combination of circumstances for success in research. You must first have as the teacher one who after long seeking has found; who has seized boldly, as it were, the thorns that beset his own path in the hope of making it a little easier for those who should come after; who enhances the value of life and work by drawing others into the great vortex of the struggle for truth. This is the man who alone can kindle enthusiasm in his disciples. A candle can only be lighted from another burning candle. As regards the qualifications of the true student, he is one who comes seeking at all cost to know. It is knowledge itself and not the accessories of knowledge—fame, comfort, power—that should be all in all to him. The seeker after knowledge must fix his eye on the distant goal of truth itself. Under these conditions, we may expect good results in researches of enduring importance. It must however, be remembered that even out of a number of earnest students, there can only be a few who can succeed in striking out a new path.

Of the future of research work in India, he says :—

I think, there is a great future for such work in India. First, on account of favourable conditions in the tropics, we have a wealth of biological material unavailable to the Northern laboratories. The Indian mind is again characteristically synthetic; it refuses to recognise artificial divisions. The greatest work for the future lies in the borderlands. Work of this description would require unremitting toil, great patience and indomitable persistence. In these qualifications some of our students will not be found wanting. At present, they find little scope for the satisfaction of the nobler aspirations—not the mere gratification of personal ambition—but the service which they can render by bringing their contribution to the store of the world's knowledge.

In 1925, he foreshadowed the Research Institute in a speech delivered at Calcutta :—

This recognition that the advance of human knowledge will be incomplete without India's special contributions must be a source of great inspiration for future workers in India. His countrymen had the keen imagination which could extort truth out of a mass of disconnected facts and the habit of meditation without allowing the mind to dissipate itself. Inspired by his visits to the ancient Universities at Taxila, at Nalanda and at Conjeevaram, Dr. Bose had the strongest confidence that India would soon see a revival of those glorious traditions. There will soon rise a Temple of Learning where the teacher, cut off from wordly distractions, would go on with his ceaseless pursuit after truth, and dying, hand on his work to his disciples. Nothing would seem laborious in his inquiry; never is he to lose sight of his quest, never is he to let it be obscured by any terrestrial temptations. For his is the Sanyasin spirit, and India is the only country where, so far from there being a conflict between science and religion, knowledge is regarded as religion itself. Such a misuse of science as is now unfortunately in evidence in the West would be impossible here. Had the conquest of air been achieved in India, her very first impulse would be to offer worship at every temple for such a manifestation of the divinity in man.

On the 30th November 1917, on his fifty-ninth birthday, however, Dr. Bose opened the Research Institute. It was done with due ceremony, and the speech he delivered in dedicating it to the Nation is one of the finest of his public utterances. The address bespeaks a scientific mystic carrying on his brows " the calm wisdom of his Vedic heri-

tage." Dr. Bose is seen in it to be not merely the scientist searching for truth with many a sigh, with his eye fixed on the minutest miracles of detail but also as a dreamer and idealist. We catch a glimpse of the very soul of the East and hear the saintly accents of renunciation in words like these :—

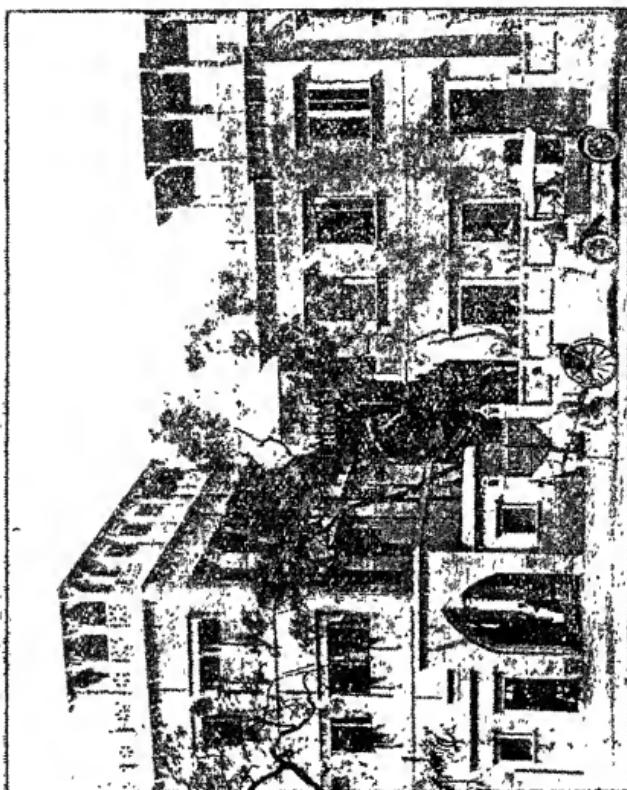
Not in matter but in thought, not in possessions but in ideals are to be found the seeds of immortality. Not through material acquisition but in generous diffusion of ideas and ideals can the true empire of humanity be established.

That Dr. Bose's researches are inspired by a great idea will be seen from these words of his :—

The ideal of giving, of enriching, in fine, of self-renunciation in response to the highest call of humanity is the other and complementary ideal. The motive power for this is not to be found in personal ambition but in effacement of all littlenesses, and uprooting of that ignorance which regards anything as gain which is to be purchased at others' loss. This I know, that no vision of truth can come except in the absence of all sources of distraction, and when the mind has reached the point of rest.

Speaking of the gallant band of disciples he has gathered round him, he said ;—

Public life and the various professions will be the appropriate sphere of activity for many aspiring young men. But for my disciples, I call on those very few, who, realising some inner call, will devote their whole life with strengthened character and determined purposes to take part in that infinite struggle to win knowledge for its own sake and see truth face to face.



THE BOSE RESEARCH INSTITUTE, CALCUTTA.

The Institute is meant for the advance of science and the diffusion of knowledge. The civic and public diffusion of knowledge is to be "without any academic limitations, to all races and languages, to both men and women alike and for all time to come."

The lectures given here will not be mere repetitions of second-hand knowledge. They will announce, to an audience of some fifteen hundred people, the new discoveries made here, which will be demonstrated for the first time before the public. We shall thus maintain continuously the highest aim of a great seat of learning by taking active part in the advancement and diffusion of knowledge. Through the regular publication of the transactions of the Institute, these Indian contributions will reach the whole world. The discoveries made will thus become public property. No patent will ever be taken. The spirit of our national culture demands that we should for ever be free from the desire of utilising knowledge for personal gain. Besides the regular staff, there will be a selected number of scholars, who, by their work, have shown special aptitude, and who would devote their whole life to the pursuit of research. They will require personal training, and their number must necessarily be limited. But it is not the quantity but quality that is of essential importance.

The Institute will not shut its doors against foreign students, as some English institutions do. For, as Dr. Bose said :—

It is my further wish that, as far as the limited accommodation would permit, the facilities should be available to workers from all countries. In this I am attempting to carry out the traditions of my country, which, so far back as twenty-five centuries ago, welcomed all scholars from different parts of the world, within the

precincts of its ancient seats of learning at Nalanda and at Taxila.

Of its future, he observed :—

These are the dreams that wove a net-work round my wakeful life for many years past. The outlook is endless for the goal is at infinity. The realisation cannot be through one life or one fortune, but through the co-operation of many lives and many fortunes. The possibility of a fuller expression will depend on very large endowments. But a beginning must be made, and this is the genesis of the foundation of this Institute. I came with nothing and shall return as I came; if something is accomplished in the interval, that would indeed be a privilege. What I have I will offer, and one who had shared with me the struggles and hardship that had to be faced, has willed to bequeath all that is here for the same object. In all my struggling efforts, I have not been altogether solitary. While the world doubted, there had been a few, now in the city of silence, who never wavered in their trust.

LECTURES IN THE INSTITUTE

Since the foundation of the Institute, Dr. Bose has delivered a series of thought-provoking discourses on scientific subjects. Distinguished men from the Universities and public life have witnessed his remarkable instruments functioning what to the lay world appears as nothing short of miracles. In January 1918, Dr. Bose explained, under the auspices of Lord Ronaldshay, the Governor of Bengal, the Mystery of the Praying Palm Tree, when he made mention of a new instrument of his own

design and make, the Crescograph, which was exhibited at the Institute a fortnight hence. Lecturing on the Revelations of Plant Life, he showed the working of his perfected instrument—an apparatus that gives a visual demonstration of movements far beyond the highest powers of a microscope. The end of the month saw him in Bombay, lecturing on his favourite subject, "The Unity of Life." The lecture was illustrated by lantern slides and an instructive exposition was given of his discoveries in plant life. Dr. Bose also explained the principle of his Resonant Recorder.

HIS LATEST TRIUMPHS

It was about this time that Dr. Bose's private laboratory was visited by His Excellency the Viceroy, Lord Chelmsford, accompanied by the Governor of Bengal. Their Excellencies took so great an interest in his discoveries that they remained there for full two hours. Subsequently, Dr. Bose succeeded in accomplishing a feat, which was so long considered utterly impossible. This is the transplantation of trees in perfect condition. At an experiment in Calcutta, he first rendered

the trees unconscious by the action of suitable narcotics and thus saved the two trees from the shock due to uprooting. Now, as they were planted again, they are growing vigorously.

Another triumph of Sir Jagadish was the High Magnification Crescograph. This is one of his unique inventions. It can magnify and record the growth of plants in as short a period as a single second. The highest power of the microscope stands dwarfed by its side by many thousand times. This instrument will, no doubt, bring about a revolution in the scientific world, especially in the Agricultural Department.

In January, next year, Dr. Bose dealt with the mysterious phenomenon of the recurrent opening and closure of the flowers. This discourse was entitled "The Night Watch of *Nymphaea*." This was followed in February with a discourse on "Wounded Plants."

Dr. Bose subsequently left for an extensive tour in Europe where he was received and honoured by the various Universities. He lectured in London, Paris, Berlin, Vienna and

several places, and his demonstrations were witnessed by the leading scientists and distinguished men of all vocations. He returned to India in May 1920 when he was presented with numerous addresses of welcome. It must be remembered, however, that he was attacked by interested scientists in England on the eve of his lecture before the Royal Society nearly 20 years ago. During his tour in 1920, he was not spared either. This time, it was Dr. Waller who attacked him. Early in 1921, Dr. Bose began another series of lectures in his Institute which attracted wide attention.

In August, Dr. Bose addressed the students of the Dacca University when he gave a lucid description of his experiments relating to plants. He summarised the results of his investigations in plant and animal life, and said:—

If he were asked what was the outcome of his recent work, he would say that it was the establishment of the great generalisation that the story of the simplest life was symbolic of all life in its diverse manifestations of growth and decay, of perception and reaction and even of conduct and behaviour. He found that an organism derived its strength from the soil which nourished its body, and the environment which, by its multitudinous

shocks, stirred it up from that lethargy which was akin to death. It is its perception and quick adjustment to change, its inherited memory of the past that called forth all its nascent powers so that in all its struggles it rose victorious above the most adverse circumstances.

Laymen often ask, of what avail are these theoretical and abstract truths? Dr. Bose has always held that the advance of knowledge and its practical application are not of conflicting interest but complimentary to each other. He illustrated this with an example from his own experiences.

Twenty-seven years ago, he was working with a very inadequate means in investigations of an abstruse character—the properties of electric waves. He was then constantly questioned about their utility. In 1895, he succeeded in perfecting an apparatus by which wireless messages could be sent and detected with the utmost certainty. But it evoked not even a flutter of interest, either in the official or non-official circles. He had his higher reward of obtaining through these investigations the first glimpse of that universal responsiveness which characterises all matter, living and non-living. It was no metaphysical speculation, but the challenge of the unknown that urged him to try to unravel some of the baffling mysteries which surround life. About this work also it had been constantly questioned:—What earthly use could there be of his investigations on plant life? And it was not till last year that some of the leading scientific bodies of the West realised that these investigations might lead to the increase of earth's food supply.

DR. BOSE AS A TEACHER

Dr. Bose must not be regarded as merely a scientist whose life has been spent within the

chambers of study and research. He has many other interests in life and his talents are also many-sided. Prof. Sudhindra Bose, writing from America, has paid him a well-deserved tribute :—

Prof. Bose is a clear, forceful and convincing speaker, is intoxicated with the fascination of his work and speaks therefore out of the fulness of his heart, and has no time for the gaudy acts of the professional spell-binders. He is intensely human and sees deeply that the essential brotherhood of man is a glowing reality and not a mere abstraction. His passion as a humanist is 'India and its people.' As a teacher and guide of young men, Dr. Bose has been remarkably successful.

What he did for them, he has himself expressed in a recent address of his to the students :—

In your congratulations for the recent honour, you have overlooked a still greater that came to me a year ago, when I was gazetted as your perpetual professor so that the tie which binds me to you is never to be severed. Thirty-two years ago, I sought to be your teacher. If I were to begin life anew, I could not have chosen a higher vocation. And for the trust that was imposed in me, could I do anything less than place before you the highest that I knew? I never appealed to your weaknesses but your strength. I never set before you what was easy, used all the compulsion for the choice of the most difficult, and perhaps as a reward for these years of effort, I find all over India those who have been my pupils occupying positions of the highest trust and responsibility in different walks of life. I do not merely count those who have won fame and success, but I also claim many others who have taken up the burden of life manfully, and whose life of purity and unselfishness had brought gleams of joy unto suffering lives.

On one occasion, he pointed out that the striking feature in the life of a teacher in India was the great devotion he evoked in the students. This ideal was highly valued both in England and India. In India, he said, the teacher is like the head of a family, revered by his pupils deeply—a reverence which is often expressed by the pupils touching the feet of the Master. This is not a servile act, but one of respect and regard, and the teacher often reciprocates the sentiment in loving his students and by being generous to their faults. Professor Bose said he had the good fortune never to have had any trouble with his students, during his 35 years of work in the College. The real secret of success was in trying to look at things from the students' point of view and to cultivate a sense of humour.

PUBLIC SERVICES COMMISSION.

As a teacher, Dr. Bose has always stood for the dignity and independence of the profession. He has spoken strongly against attempts made to discriminate between white

and black in the services. In his evidence before the Public Services Commission in 1913, he stood for equality of opportunity in the services. He said:—

Regarding the question of limitations that exist in the employment of Indians in the higher service, I should like to give expression to an injustice which is very keenly felt. It is unfortunate that Indian graduates of European Universities who have distinguished themselves in a remarkable manner do not, for one reason or other, find facilities for entering the higher educational service.

As teachers and workers, it is an incontestable fact that Indian officers have distinguished themselves very highly, and anything which discriminates between Europeans and Indians in the way of pay and prospects is most undesirable. A sense of injustice is ill-calculated to bring about that harmony which is so necessary among all the members of an educational institution, professors and students alike.

HIS PATRIOTISM

Dr. Bose is one of the greatest patriots of India. His life is a living example of the many-sided character of our Renaissance. Patriotism in a country like India comes often to be identical with politics. But it is our singular good fortune that it has found its expression not only in politics, but also in the sciences and the arts. The discoveries of Dr. Bose have shed lustre on this country. He has raised his land in the

estimation of the world and shown that, once again, India can teach the world, as of yore. By opening the Research Institute and attracting through it the best aspirants after knowledge from all over the world, he has done more than any other to create and ensure the intellectual hegemony of the East. The institute revives the splendour of Taxila and Nalanda, whose glorious memories fired the ambition of his youth.

If Dr. Bose has set by his life an example of high-souled patriotism, he has also given conscious expression to it in many of his speeches. In Madura, he asked, "Are we a living nation ?" and said :—

In travelling all over the world which I have done several times, I was struck by two great characteristics of different nations. One characteristic of certain nations is living for the future. All the modern nations are striving to win force and power from Nature. There is another class of men who live on the glory of the past. Now what is to be to the future of our nation ? Are we to live only in the glory of the past and die off from the face of the earth, or to show that we are worthy descendants of the glorious past and to show by our work, by our intellect and by our service that we are not a decadent nation ? We have still a great and mighty future before us, a future that will justify our ancestry. In talking about ancestry, do we ever realise that the only way in which we can do honour to our past is not to brag of what our ancestors have done but to carry out in the future something as great as, if not greater than, they ?

Are we to be a living nation, to be proud of our ancestry, and to try to win renown by continuous achievements? These mighty monuments that I see around me tell us what has been done till very recent times. I have travelled over some of the greatest ruins of the Universities of India, I have been to the ruins of the University of Taxila in the farthest corner of India, which attracted the people of the West and the East. I had been to the ruins of Nalanda which invited all the West to gain knowledge under its intellectual fostering. I had been all there and seen them. I have come here also and I want to visit Conjeeveram. But are you to foster the dead or to try to bring back your University in India and drag once more from the rest of the world people who would come down and derive knowledge from India? It is in that way and in that way alone we can win our self-respect, and we can make our life and the life of the nation worthy. The present era is the era of Temples of Learning. In order to erect Temples of learning, we require all the offerings of our mighty people. We want to erect temples and *viharas*, which are so indispensable to the study of Nature and her secrets. It is a problem which appeals to every thoughtful Indian. It is by the effort of the people and by their generosity that all these mighty temples arose; and now are we to worship the dead stones or are we to enact living temples so that the knowledge that has been made in India shall be perpetuated in India? I receive requests from the different Universities in America and Germany to allow students from those countries to come and learn the science that had its birth in India. Now is the knowledge to pass beyond our boundaries, so that, again in future time, we have to go to the West to get back this knowledge, or are we to keep this flame of learning burning all time?

DR. BOSE, A SCIENTIFIC MYSTIC

Even as a scientist, Dr. Bose carries on his brows the "calm wisdom of his Vedic heritage." He is a scientific mystic. In his investigations, he has often been reminded of

the symbolic fresco in the dim caverns of Ajanta, depicting the cosmic dream of the eternal struggle of light with darkness. As he went on, however, he not only succeeded in detaching so often the real from the obscuring veil of darkness but came to find an all-pervading unity in the universe. Every step in advance in this vast simplification—making them all appear as various rhythms and harmonies of a single fundamental sequence—only drove the question deeper:—

“Who is he that sits within striking the molecules this way and that? Or what is he, pure, free, ever the witness? Who interprets the records of strain, using the brain as his galvanometer, and discarding alike the laboratory and its instruments when these no longer please him?”

He said in concluding his lecture at the Royal Institution on the 10th of May 1902:

“It was when I came upon the mute witness of these self-made records and perceived in them one phase of pervading unity that bears within it all things; the mote that quivers in ripples of light, the teeming life upon our earth, and the radiant suns that shine above us—it was then that I understood for the first time a little of that message proclaimed by my ancestors on the banks of the Ganges thirty centuries ago:—

“They who see but one in all the changing manifoldness of the universe, unto them belongs eternal truth, unto none else, unto none else.”

A NEW DISCOVERY

Sir Jagadish made yet another tour to Europe.* In the summer of 1928, he left for Europe in connection with the League of Nations' Meeting in Geneva. As might be expected, he had an interesting time of it in England and in the Continent.

Lecturing at the University College, London, before a distinguished gathering of eminent scientists, Sir Jagdish Chandra Bose announced his sensational discoveries with regard to plant life. His newly invented Recorder revealed the hitherto invisible cellular throbings in the interior of plants. He placed the stem of an ordinary plant in an electric chair and electrocuted it, causing it to shudder convulsively until it died.

Sir Jagdish Chandra Bose's new experiments on the movement of sap have completely demolished the old theory that the rise of sap was due to transpiration from leaves. He has previously shown that the sap movement is active in leafless trees in spring time. Experimenting with an isolated stem from-

which leaves and roots had been removed, he made the sap flow up or down at will.

Thus the Indian pioneer of science has three times astonished the world with the results of his discoveries, first on the property of invisible electric waves, then in revealing the inner and invisible activities of plant life, thirdly, in establishing the unique generalizations of the unity of all life.

From time to time, Sir Jagdish had published the results of his researches in volumes which have received the highest encomiums from *savants*. These valuable researches scattered in different books were now put in one comprehensive volume entitled "The Motor Mechanism of Plants." (Longmans Green & Co.) In the preface to this book, Sir Jagadish recalls that as long ago as 1920, doubts were cast upon the reliability of the results he had obtained, but that a committee of Fellows of the Royal Society, including Sir William Bragg and the late Sir William Bayliss, reported that they were satisfied that the growth of the plant and its response to stimulation were correctly record-

·ed by his instruments at a magnification of one ·to ten million times.

Sir Jagadish gives in this book a full account of all the experiments he has made, and the results achieved not only with regard to the visible external movements but also to the invisible internal movement concerned with the propulsion of the sap. Sir Jagadish has a happy knack of explaining abstruse subjects with great lucidity, and his presentation of what might appear to the lay reader as a highly technical subject, makes it of absorbing interest.

INFLUENCE ON MODERN THOUGHT

Mr. Bernard Shaw, after seeing one of Bose's ·demonstrations, presented him with a special ·edition of his collected works bearing the inscription "From the least to the greatest biologist." Romain Rolland sent him his *Jean Christophe* with the note "To the Revealer of a New World." The editor of the SPECTATOR of London organized a lunch in his honour where the greatest literary people like Galsworthy, Noyes, Rebecca West, Norman Angel, Yeats, Brown and others came

to offer their congratulations to one who had, in so eminent a degree, enriched human thought. They asked him to tell them the significance of his discoveries, and the aspirations of India and the influences which contributed to the new renaissance.

Bose's address in reply produced the most profound impression among his distinguished audience who had no difficulty in realizing the baselessness of the slander against the people of India that had been circulated for propagandist purposes. THE SPECTATOR published several articles from the pen of its literary editor, who also contributed a striking article in the FORTNIGHTLY REVIEW; the following extracts are taken from these articles :

“ In Bose is seen an invincible, perhaps immortal quality which has given a permanence to the Indian civilization such as no other nation has approached. In Sir Jagadis the culture of thirty centuries has blossomed into a scientific brain of an order which we can not duplicate in the West. We find in him a spiritual sense difficult to define,

intangible yet evident, pre-eminently of the East; the quality out of which all great faiths have grown.

He subsequently visited France and Austria where he was entertained by leading scientific societies. He was given a great ovation at the University of Vienna by a large audience which included members of the cabinet and leading scientists.

Welcoming Sir J. C. Bose on behalf of the University, Professor Molisch, Plant Physiologist, rejoiced that Sir J. C. Bose's wonderful discoveries would benefit humanity not merely by advancing pure science but by their practical application to agriculture and medicine. He said Sir J. C. Bose had the unique distinction of having his revolutionary doctrine acclaimed in his life-time as testified by his election as an honorary member of the Academy of Science, Vienna.

Sir Jagadish also delivered two lectures at the Vienna University, which were attended by distinguished audiences. In a special lecture, eminent physiologists and doctors were afforded the opportunity of witnessing his new

experimental methods of testing the efficacy of new Indian drugs and reviving activity and animal heat. The audience gave loud expression to their admiration of the demonstrations.

The conquest of Vienna scientists was so complete that an official letter was addressed to the Viceroy of India by the Rector of the University of Vienna that Sir J. C. Bose's researches have opened out a new gate of knowledge of the highest theoretical and practical importance.

IN EGYPT

The interest in Dr. Bose's discoveries was so great that H. E. Nakhia Pasha, the Minister of Agriculture of Egypt, approached the British Foreign Office through the High Commissioner saying that the Egyptian Government was most anxious for his visit to Alexandria and Cairo as the guest of Government. H. M. the King and his officers received him with the greatest cordiality, and we read from an account of the tour by Dr. Sircar, who accompanied the scientist through Europe and Egypt, that special arrangements had been made for his reception at Cairo where he was

invited to visit all the great educational institutions. The Government also requested Dr. Bose to choose some Egyptian scholars as his disciples.

The most important event in Cairo was, however, the great lecture illustrated by demonstration which was organised at the Royal Geographical Society. The large auditorium was filled with all the leading members of the various nationalities, the representatives of the British University, the members and the highest officials of the Egyptian Government. "Never was a contact of the East and the West more intimate, and never was the mutual co-operation between the two in world's prosperity so clearly demonstrated as on that eventful evening."

A leading Egyptian paper, *Al Mokattam*, in referring to Sir Jagadish, wrote: "The Orientals rejoice at the name of Sir Jagadish Bose by whose efforts new branches of knowledge have been opened upon science. Let us draw a lesson from the genius of Sir Jagadis, and strive after his example for the welfare of our country and the welfare of the whole world."

RETURN HOME

After the triumphal tour in Europe and in the near East, Sir Jagadish returned to India in September 1928, and was accorded a great ovation in Bombay. "Is there anything you cannot do if you put your whole mind to it?" was the stern question put by Sir Jagadish replying to an address presented by the Youth League of Bombay on landing.

Sir J. C. Bose observed :

When a disciple comes to me, I ask him whether he would carry out certain duties to be entrusted to him. He generally answers, 'I will try.' That betokens not true humility, but cowardice, which seeks a loop-hole of escape.

It is the habit of weakness to throw blame on others, on the University, on Government on unfavourable circumstances in general. It is not for a man to complain of circumstances, but bravely accept them, confront them and dominate them. Learn once for all to choose what you are going to do, and say I will.

Sir J. C. Bose finally exhorted the youth to get rid of narrow provincialism, attain the highest manhood and womanhood, realise the privilege of being born at a time when the country needed them most. Realise, he said, there could be no happiness for any one unless it was won for all. Pursue the doctrine of

·strength and build up the Greater India, yet to be.

But the world-famous conclusions of Sir Jagadish Bose regarding the similarity of plant and animal nerve tissue were contested by Prof. R. H. Dastur, Chief Professor of Botany in the Royal Institute of Science, Bombay, in the course of a lecture soon after the return of the great scientist.

Plants and animals, he declared, were radically different. Sir Jagadish Bose had assigned the role of nervous tissue to the tissue known as "phloem," whose main function was the conduction of food materials.

Sir Jagadish declined to enter into a challenge with a "mere novice." "The greatest scientists in the world have accepted my theory," he said, "and I can not condescend to enter into a controversy with a novice in science." "My object," continued Sir Jagadish "is to bring the Science of the East and of the West into closer affinity for the benefit of humanity."

Sir Jagadish has continued to receive increasing honours from seats of learning in India as well. He was invited by the Allaha-

bad University to deliver the Convocation Address in November, 1928. The Governor, as Chancellor, presided over the Convocation when the degree of Doctor of Science, *honoris causa* was conferred on him. In introducing Sir Jagadish, Sir Malcolm Hailey said if India could produce such great men as Mr. Gandhi, Dr. Tagore and Sir J. C. Bose in spiritual, literary and scientific spheres with reputations which were world-wide, others could follow their example.

Dr. Bose's address to the Convocation was marked by an inspiring message to the youth of the country, bestirring them to a life of action.

"It was action and not passivity, that was glorified in the heroic India of the past. There can be no happiness for any of us unless it has been won for all. When a great call is echoing through the land, we can not lead a life of ignoble ease, or even seek personal salvation.

Go out then in life's great adventure: the more difficult the task, the greater is the challenge. When you have gained the vision of a purpose to which you can and must dedicate yourself wholly, then the closed door will open and the seemingly impossible will become fully attainable.

BIRTH-DAY CELEBRATIONS

In the meanwhile, a great movement was in progress to celebrate, on the 1st December,

Sir Jagadish Bose's 70th birthday. The movement was inaugurated by the leading intellectuals of the country in which others eminent in various other callings joined. The function was held in the Bose Institute where had gathered the leading lights of Calcutta and all his students and admirers. Thus in an enchanting surrounding of flowers and plants and of myriads of coloured lights, and in a supremely Oriental atmosphere, Sir Jagadish and Lady Bose seated themselves on a raised dais in the lovely garden of the Institute, and received congratulations from various academical institutions of Calcutta, the principal universities of India, the Government of India and several other institutions and renowned personages of the world.

Messages of congratulations were then read from Dr. Rabindranath Tagore, and other distinguished men and heads of educational institutions all over India, besides leading officials. From abroad, came messages of good will from the Editor of the NATURE, Prof. Gobel of Munich University, Sir John Farmer, Romain Rolland, the Egyptian Minis-

ter of Agriculture, Mr. Bernard Shaw, Sir John Drinkwater and Mr. Evelyn Wrench, Editor, SPECTATOR.

The Education Minister of the Chinese Government at Nanking cabled as follows :

Many happy returns to life devoted to discovering ultimate truth and mystery of life. World looks to you to lift science into realm of spiritual reality. All Asia shares in your glory.

Sir Jagadish, in the course of a short but feeling reply, said :

The struggle in which I have been engaged for the last forty years has been to win for India a recognised place among the federation of nations by her contributions for extending the boundaries of knowledge. The world is to-day divided into warring hosts threatening destruction of civilisation. There is only one other alternative to save the world from ruin, and that is by intellectual co-operation for the common benefit of mankind; And this has been the message of the East, the latest expression of which I have just received from China for lifting science into the realm of spiritual reality and declaring that like the unity of all aspirations by which alone continuity of human civilisation can be assured.

And in a final message to his countrymen and to the people of the West, Sir Jagadish enunciated his doctrine of strength and of undying hope :—

Who are the people of India ? If one reads the history of this country aright, he will realise that India has a great assimilative power by which many races and people come to regard this country as their home, and in the service of which they gain their highest reward.

It is not the lure of the East that calls them, but loyalty to the country of their adoption. There is an Unseen Power which presides over the Nation's destiny, and guides the onward march of the children of this great land inspiring them with a burning faith in the renewal of India's ancient greatness. It was action and not weak passivity that was glorified in heroic India of the past. There can be no happiness for any of us, unless it has been won for all; I would, therefore, urge the doctrine of strength and of undying type.

Dr. P. C. RAY*

BIRTH AND PARENTAGE

Dr. Prafulla Chandra Ray was born in 1861 at Raruli-Katipara, a small village now in the District of Khulna, of a family well-known for generations in that part of Bengal. The village is situated on the bank of the river Kapotaksha, immortalised by the great Bengali poet, Michael Madhusudan, † in a sonnet written at Versailles. His father, the late Harish Chandra Ray, who died in 1894 at the age of 69—a good Persian scholar imbued with the writings of Sadi and Hafiz—was a student of the Krishnagar College in the early forties of the last century, when the celebrated Captain D. L. Richardson was its Principal. He was a well-

*The writer of this sketch has made free use of sketches of Dr. Ray's life which appeared in the pages of the "Indian World," the "Calcutta University Magazine" and the "Century Review," and also of appreciations written by some of Dr. Ray's pupils notably Mr. F. V. Fernandez.

† *Michael Madhusudan Dutt: A sketch of his life and career.* Price As. 4 (G. A. Natesan & Co., Madras).

read man who held enlightened views on many social questions and was a pioneer in introducing English education in his own district. Harish Chandra was a member of the British Indian Association in the early sixties of the last century, and was well acquainted with, among others, the late Raja Digambar Mitra, Kristo Das Pal, Sishir Kumar Ghosh and Pandit Iswar Chandra Vidyasagar. The local Model Vernacular School, which was founded and maintained mainly at the expense of the late Harish Chandra Ray, has now grown into a Model English High School, and is located in the very ancestral house of Dr. Ray, for the up-keep of which he spends annually a handsome amount. This ancestral home of Dr. Ray is more than a century old, and is partly in a dilapidated condition, but is still considered to be one of the finest buildings in the whole district.

EDUCATION

Dr. Ray received his early training at his father's school; but his father, anxious that his sons should receive the best possible

education, settled down at Calcutta towards the end of 1870. Young Prafulla Chandra was admitted as a pupil of the Haré School immediately, and was there for four years. In 1874, he got a severe attack of dysentery and suffered from it for nearly two years and, consequently, was absent from school for a long period; but he utilised this time in devouring the contents of a splendid library got together by his father and his eldest brother. Being of very regular habits and disentangled from the trammels of ordinary school lessons—he kept up his studies without let or hindrance, in spite of his malady, and got passionately attached to the works of Goldsmith, Addison and some other classical English authors. When sufficiently recovered from his malady, he took his admission into the Albert School of Calcutta, then in the heyday of its glory under the rectorship of the late Krishna Vihari Sen, and here he at once made his mark as a brilliant student. From Krishna Vihari young Prafulla Chandra also imbibed a deep and abiding love of English literature. At this time, he was

a constant listener to the lectures and sermons of Keshub Chandra Sen and was slowly attracted to the Brahmo Samaj of which he has been a member since 1882. At this period of his life (about 1875-77), he also caught the enthusiasm inspired by the eloquence of the late Ananda Mohan Bose and Surendranath Banerjea and felt the impulses of a higher patriotic life.*

From 1879 to 1882, he was a student of the Metropolitan Institution. He has often said that the one fascination he had for joining Vidyasagar's College was that he should be able to sit at the feet of Babu Surendranath Benerjea. Indeed, the exposition of Morley's *Burke* and Burke's *Reflections on the French Revolution* from the lips of the great Bengalee orator made a life-long impression on Dr. Ray. All this time, young Ray was also a student of the Presidency College (in the Scientific Department) where he attended the lectures of Sir John Eliot in Physics and of Sir Alexander Pedler in Chemistry. Dr. Ray's father,

* Vide "Essays and Discourses" of Dr. Ray—Article on *Ananda Mohan Bose*.

having lost in the meantime a considerable portion of his ancestral fortunes, was precluded from giving his brilliant son the benefit of an education in England. Young Ray, however, slowly and quietly, prepared himself for the Gilchrist Scholarship Examination, and it is singular that his father and other relations were kept entirely in the dark about his intentions, his eldest brother alone having been taken into his confidence. In 1882, Ray proceeded to England as a Gilchrist Scholar and studied at Edinburgh for six years. Although his taste and inclination lay towards English literature and history, he realised that the future progress of India was bound up with the pursuit of science, and thus he gradually allowed himself to be weaned away from his former studies. At Edinburgh, he was the pupil of the celebrated Peter Guthrie Tait and of Alexander Crum Brown—two mighty intellects in the departments of Physical Science and Chemistry—and through their teachings, he shortly came to be devotedly attached to the study of Chemistry. It will be interesting

to note here that amongst his fellow-students were Prof. James Walker, F.R.S., of Edinburgh and the late Prof. Hugh Marshall, F.R.S., of University College, Dundee. Writing from the University of Edinburgh, under date 5th April, 1888, Prof. Crum Brown states :—

I have known Dr. P. C. Ray since he came to this University in 1882, and have watched his career with much interest. Having laid a sound foundation of general scientific knowledge, he devoted himself especially to Chemistry. He took the degree of B.Sc. in 1885, and that of D. Sc. in 1887. He held the Hope Prize Scholarship in Chemistry during the year 1887-88. He worked in the Chemical Laboratories during the Summer and Winter Sessions, from May 1883 till March 1888, latterly assisting Dr. Gibson and myself in the work of the Laboratory. As much of his work was done under my own observation, I can speak with confidence as to his ability and knowledge. He has an extensive and sound acquaintance with all branches of theoretic Chemistry and is a careful and accurate analyst. He has shown that he has the capacity for original investigation—his thesis for the degree of D. Sc. being a piece of excellent analytical work, well arranged, and thoroughly and conscientiously carried out.

“ INDIA BEFORE THE MUTINY ”

Although Chemistry literally claimed him as her own, Dr. Ray still continued to be a close student of English politics and of Indian Economics. His *Essay on India before and after the Mutiny*, written on the eve of his appearance for the B. Sc. Examination at Edinburgh, bears impress of mature

study of Indian problems. The Essay was warmly appreciated at the time, and Principal Sir William Muir pronounced it as, "bearing marks of rare ability." The leading newspaper of the Scottish capital, the *Scotsman*, observed: "It is a most interesting little-volume, and we do not profess to wonder in the least that it has earned a considerable amount of popularity. It contains information in reference to India which will not be found elsewhere, and it is of the utmost notice."

John Bright, in acknowledging a copy of the booklet, wrote a long letter to the author in which he said:—

I regret with you and condemn the course of Lord Dufferin in Burma. It is a renewal of the old system of crime and guilt, which, we had hoped, had been for ever abandoned. There is an ignorance on the part of the public in this country and great selfishness here and in India as to our true interests in India. The departures from morality and true statesmanship will bring about calamity and perhaps ruin, which your children may witness and deplore.

AS PROFESSOR

On his return to India, he joined the Presidency College of Calcutta as a Professor, and since that year (1889) he has practically



SIR P., C. RAY.

confined all his attention to his Chemical researches. The results of his devotion at the Chemical Laboratory of this College, particularly in the years between 1896-1898, were embodied in his first scientific publication under the title of "Chemical Research at the Presidency College." This little brochure was "affectionately inscribed" to "my friend, Prithwis Chandra Ray, author of the *Poverty Problem in India*," and at once established his reputation as a great Indian scientist. In 1904, he was deputed by the Government of Bengal to visit the principal Chemical laboratories of Europe, and was everywhere received with open arms by chemists and *savants*. At a meeting of the French Academy of Sciences, Mr. Troost welcomed Dr. Ray in words of generous appreciation on behalf of that august body.

A CAPTAIN OF INDUSTRY

The story of the foundation and growth of the Bengal Chemical and Pharmaceutical Works reads like a romance. It has proved to the world abroad that Indians possess

a marvellous brain, that in spite of unfavourable circumstances, they can build up a vast industry by the virtue of their perseverance and tenacity. The B.C.P.W. is a standing monument to the industry and intellectual capacity of Dr. Ray. He had to fight against enormous odds in laying deep the foundation of this business. "The Bengal Chemical and Pharmaceutical Works had its birth," observed its founder, "in the early struggles in the dark and dingy rooms of a house in Upper Circular Road, and it started with the modest sum of Rs. 800." Though he was then a Professor of the Presidency College, his income was only Rs. 250 a month. He had in those days to pay off some ancestral debts; besides, his charity was never restricted to one or two students. With this meagre income, he worked wonders in the field of industry. Many young men complain of the lack of sufficient capital to carry on business, but here is the concrete example of one of the greatest sons of Bengal who managed to establish a good business even without sufficient funds. One of the many causes of the failure of many

an indigenous industry in India is the lack of purpose and firm determination. When the wave of Swadeshi enthusiasm passed over the country, there came to light many new industries, but how many of them are found now in a prosperous condition? How many have survived in the struggle for existence? Their number can be counted on one's fingers. The industry set up by Dr. Ray many years before the Swadeshi awakening, however, is still as full of hope and promise as ever.

That "dark and dingy" room saw the birth of this new industry. There could be found in those days various utensils strewn about, containing sulphuric acid here and nitric acid there, all in the process of distillation. The young workers were busy making a thousand and one things and carrying out experiments.

Fortunately for Dr. Ray, he received the co-operation and assistance of a few able workers, who were ready to do their "bit" for the benefit of chemical industry in India. First came his old friend, Dr. Amulya Charan Bose. He was a sincere worker in

this field. He assisted Dr. Ray with all his heart and never looked for gain. Actuated by the love of country, his aim was always free from gross personal motives. Another young worker, Satish Chandra Sinha, joined them soon after passing the M. A. Examination. He was really a martyr to the cause of science, for shortly after, he died of prussic acid poisoning. Another silent worker was Prof. Chandra Bhusan Bhaduri, who never advertised himself. It has been maintained that when the story of the development of the chemical industry in Bengal comes to be written, his name is sure to obtain a high rank, as one of the early promoters and pioneers.

Thus the Company, originally started as a small private concern for the manufacture of medicines and other chemical preparations, has now rapidly increased its many-sided activities. Year after year, the Company made large strides, and now it stands as one of the most successful industries in India. As we have said before, the Company was, at first, a private concern, but as the field of its activity began to expand rapidly, Dr. Ray did not

think it proper to keep the whole income to himself. His patriotism prompted him to make it a limited company, throwing open its shares to all.

"It has always been a fixed principle with the Directors of this business," said Dr. Ray, the Founder-Director, "not to take in any one as a chemist whose knowledge is not up to the M. Sc. standard of our University." The Company has now a number of expert chemists working. They are all former students of Dr. Ray. Here is an industry which has been conceived, initiated, and managed solely by Bengali brains, energy and pluck, and it has never been necessary to call in the aid of any foreign "experts."

As Dr. Travers of the Indian Scientific Institute said, the Bengal Chemical Works is a piece of research work for which Professor Ray and Mr. C. Bhaduri ought to be proud. In the words of the same authority, "the construction and management of the works is the work of the past students from the Chemistry Department of the Presidency College, acting under the advice of these gentlemen. The design and construction of

the sulphuric acid plant and of the plants required for the preparation of drugs and other products involved a large amount of research work of the kind which is likely to be of the greatest service to this country, and does the greatest credit to those concerned." (CENTURY REVIEW.)

LITERARY INTERESTS

Dr. Ray is a man of many interests. He has not been content with only building up an industrial concern but takes a keen interest in Bengali literature and is himself a careful student of it. Some years ago, he was called upon to preside over the Provincial Literary Conference in which he read a remarkable paper on the "Place of Science in Literature."* He has contributed many articles to several Bengali periodicals, besides writing occasionally to the English press in India.

Of Shakespeare, Dr. Ray is immoderately fond, and is never tired of reading and re-

* For a translation of the paper, see "Essays and Discourses, etc."

reading his works. Emerson, Carlyle, Epictetus and Marcus Aurelius have deeply tinged his life. His favourite novels are those of Thackeray, George Eliot and Dickens,—he cannot tolerate any present-day novelists—not even Hall Caine or Marie Corelli.

DR. RAY'S RESEARCHES AND DISCOVERIES

It was in December, 1895, that Dr. Ray rose to fame and became known to the scientific world by his celebrated discovery of mercurous nitrite. In his presidential address delivered before the Asiatic Society in 1896, Mr. (now Sir Alexander) Pedler said :—"Dr. P. C. Ray, by his discovery of the method of preparation of this compound, has filled up a blank in our knowledge of the mercury series."

The reactions of nitric acid with mercury have been a favourite subject with the chemists since the 15th century A.D., if not earlier. Dr. Ray, however, was the first not only to point out distinctly but to isolate the initial product, namely "mercurous nitrite." This remarkable discovery is now almost a matter of ancient history, but how it was welcomed, and received at the time will be

evident from the extracts given from two scientific journals quoted below :—

NATURE, 28th May, 1896, thus reviewed Dr. Ray's discovery of Mercurous Nitrite :—

The *Journal of the Asiatic Society of Bengal* can scarcely be said to have a place in our Chemical Libraries; the current number, however, contains a paper by Dr. P. C. Ray of the Presidency College, Calcutta, on mercurous nitrite, that is worthy of note. During a preparation of mercurous nitrate by the action of dilute nitric acid in the cold on mercury, yellow crystals were deposited which, upon examination, proved to be mercurous nitrite. The analysis proved somewhat difficult..... The fact, that the nitrite is stable in strongly acid solutions, is an additional proof of the views held by Dr. Divers as to the "nitronic" constitution of the nitrites of copper, mercury and bismuth. The stability of silver nitrite towards nitric acid has already been noticed by Acworth and Armstrong, and by Russell, and the behaviour of mercurous nitrite is closely analogous. Dr. Ray proposes, in a subsequent communication, to give the results of an attempt to prepare fatty nitro-derivatives from this compound.

THE CHEMIST AND DRUGGIST of London,
25th July, 1896, observed :—

It has been left to a Bengali chemist, Dr. P. C. Ray, to demonstrate that the not unfamiliar yellow crystalline deposit that is obtained by contact of dilute nitric acid with mercury in the cold is mercurous nitrite. The substance is not so much as mentioned in "Roscoe" and "Schorlemmer," nor is there any reference to it in "Watt's Dictionary of Chemistry." Dr. Ray's discovery has been well received in Chemical circles.

Among the famous chemists of Europe, Sir Henry Roscoe and M. Berthelot were the first

to congratulate Dr. Ray and welcome his discovery.

Mercurous nitrite has proved to be the fruitful parent of an interesting series of compounds, and during the last quarter of a century, Dr. Ray, singly or in co-operation with his pupils, has been incessantly busy in working them up. To an average lay reader, the details of these discoveries may not prove intelligible, and we shall therefore content ourselves with presenting the outstanding features of some of them. One very striking outcome of the earlier researches in this field has been the establishment of an identity in the properties of "monad" mercury and silver. It was at a meeting of the Asiatic Society of Bengal in 1907 that Dr. Ray read a short paper entitled "silver mercuroso-mercuric oxynitrate," and a more elaborate account of the subject based upon further investigations appeared in the JOURNAL OF THE CHEMICAL SOCIETY OF LONDON.

Dr. Ray's researches have all along shown that univalent mercury should be placed side by side with silver, and his latest paper adduces most convincing

proof in this direction. He has at last succeeded in preparing a compound of univalent mercury in which a portion of this metal is isomorphously replaced by its analogue, silver. This isomorphous or, to adopt the happy language of the greatest living authority on the subject, Groth—'vicarious' substitution of mercury by silver, will, no doubt, be welcomed by the scientific world. Why should one and the same metal play this sort of double role? We are at the dawn of a new chemistry. Sir W. Ramsay has shown that radium is slowly transformed into helium. Possibly the 20th century is destined to throw a flood of light on the duality as also on the transmutation of metals.—The EMPIRE.

It was no mean compliment which the late Professor Divers, P. R. S., paid to Dr. Ray's researches when, in a paper read before the Society of Chemical Industry in 1904 on the dissolution of metals in nitric acid, he made the following introductory remark :

The occasion for presenting the theory in a more developed form to the Society has been given by the reading last month to the Chemical Society of the important paper on mercurous nitrite by Prof. Ray of the Presidency College, Calcutta.—JOURN. SOC. CHEM. IND.

The limited space at our disposal forbids our following in detail the substance of some 80 memoirs on the subject of the 'nitrites' and 'hypo-nitrites.' The important discovery of the 'amine' nitrites by Dr. Ray and his co-worker, Mr. Jitendranath Rakshit, deserves, however, more than a passing notice, and we cannot do better than quote the brief

but graphic notice of it which appeared in the columns of a Calcutta print at the time :—

The very preliminary note on methylammonium-nitrite by Dr. Ray and Mr. Jitendranath Rakshit which was read at the last December meeting of the Asiatic Society has not, we are afraid, attracted the attention it deserves. The authors with commendable unobtrusiveness announce in this communication the preparation of a new compound which is destined to be hailed in the chemical world as a startling discovery. Sir William Ramsay, if our memory serves us right, has somewhere aptly said that a chemical process involves a marriage of elements (and of compounds as well). Now the chemical union of methylamine and nitrous acid has been the despair of successive generations of chemists; all the attempts to bring them together under the matrimonial yoke have hitherto failed, as these two compounds are mutually destructive of each other and their inter-action almost instantaneously results in the formation of methyl-alcohol and liberation of nitrogen. Indeed, this very reaction, as every tyro in organic chemistry knows, is made use of for diagnosis of primary amines. The authors have evidently proved to be efficient chemical match-makers, as in their hands methylamine and nitrous acid have not forgotten their antagonistic properties, but have agreed to be united in chemical wedlock, giving rise to a beautiful crystalline yellowish compound. We understand that Dr. Ray has already been the recipient of warm congratulations from eminent English chemists, and it would seem almost impertinent to add our own. It is believed that since the discovery of mercurous nitrite by Dr. Ray in 1895, a preliminary account of which was also communicated to the Asiatic Society at the time and which at once made the name of its discoverer known to the scientific world, the laborious researches in the Chemical Laboratory of the Presidency College have not been rewarded with so rich a find.

Another most important discovery was the preparation and volatilisation of ammonium

nitrite. The "Annual Report on the Progress of Chemistry," issued by the Chemical Society, which embodies the most important contributions on the subject by the chemists throughout the world, thus noticed in successive issues the significance of the Bengalee Chemist's discoveries from 1904 onwards :

Ray has obtained mercuric nitrite by the interaction of mercuric chloride and silver nitrite.

Ray has continued his researches on the nitrites discussing the conditions influencing the formation of ten different products of the action of nitric acid on mercury. This author has also prepared the nitrites of alkali and alkaline earth metals which are formed by the interaction of the chlorides on silver nitrite. The solutions of these nitrites may be evaporated in contact with the air without undergoing oxidation. These nitrites have a yellow colour, the depth of which increases with the atomic weight of the metal. Magnesium nitrite is the least stable of those of the alkaline earths forming, as magnesium does in many other cases, a link between the nitrites of zinc and cadmium and those of calcium, strontium, and barium. Ray and Ganguli have recently described two varieties of silver nitrite.—ANNUAL REPORT, 1905.

Continuing his patient study of the nitrites, P. C. Ray has shown that, if a solution of ammonium nitrite is heated in a vacuum, very little gas is evolved below 40° ; on cooling, most of the salt crystallises. If the temperature is raised to 70° , slow decomposition takes place, but a considerable quantity of the salt appears as sublimate.—ANNUAL REPORT, 1909.

Ray, in his long and painstaking researches on the nitrites, has studied the effect of adding various nitrates in small quantity to nitric acid while it is allowed to act on mercury. It has been found, whilst the nitrates of sodium, potassium and manganese have an accelerating

effect on the action, ferrie nitrate had a distinctly retarding effect.—ANNUAL REPORT, 1911.

During his subsequent visit to England, Dr. Ray took advantage of the opportunity to read two papers on his latest researches. The paper on the "vapour density of ammonium nitrite" has won the admiration of eminent chemists. We can only make room for two short extracts bearing upon the subject:—

THE CHEMIST AND DRUGGIST of 6th June, 1912, wrote:—

Dr. V. H. Veley, in welcoming Prof. Ray, said he was an illustrious representative of a great Aryan nation which had attained a high degree of civilisation and discovered many chemical processes when this country was but a dismal swamp. Professor Ray had shown, contrary to text-books, statements that ammonium nitrite could be obtained in a stable crystalline condition and volatilised. He concluded by paying a warm tribute to Dr. Ray and his pupils for their valuable researches on ammonium—and the amine nitrites. The chairman also extended, on behalf of the Society, a hearty welcome to Prof. Ray, endorsing Dr. Veley's remarks.

NATURE, August 15, 1912, remarked:—

Prof. P. C. Ray has added to his success in preparing ammonium nitrite in a tangible form, a further accomplishment in determining the vapour density of this very fugitive compound.

"HISTORY OF HINDU CHEMISTRY".

We have not space here to notice more in detail the contributions of Dr. Ray to the

chemical world. But no review of his life and work can be complete without a reference to his monumental work, *The History of Hindu Chemistry*, in which he has completely proved to the world at large, by reference to old Sanskrit texts, the antiquity of the knowledge of Chemistry in this country. The first volume of the "History" appeared in 1902 as a result of the persistent study and toil of fifteen years, and was so favourably received that it was necessary to publish a second edition in 1905. The second volume came out about five years after the first. M. Berthelot, the illustrious French Chemist, reviewed the first volume of the work at considerable length in the columns of the JOURNAL DES SAVANTS. We quote the concluding lines :

A new and interesting chapter has been added to the history of sciences and of human thought.

The Vice-Chancellor of the Durham University, in conferring on him the honorary degree of D. Sc., said in 1912 :—

A keen and successful investigator, he has long made his mark by contributions to scientific periodicals, both English and German, but his fame chiefly rests on his monumental 'History of Hindu Chemistry'—a work of

which both the scientific and linguistic attainments are equally remarkable, and of which, if of any book, we may pronounce that it is definitive.

And that great German author, Hermann Schelenz, one of the greatest of the living authorities on Pharmaceutical Chemistry, and author of the *History of Pharmacy* ("Geschichte der Pharmazie") went into ecstasy over Dr. P. C. Ray's *History of Hindu Chemistry*, and authoritatively declared as his deliberate opinion that the mastery of chemical processes, as elaborately described in the Hindu work, *Rasaratnasamuchchaya*, upon which Dr. Ray has copiously drawn in his *History*, shows that the Hindu chemists were far ahead of their European contemporaries of the 13th and 14th centuries A.D. In order to introduce our readers to the subject matter of this book, we can do no better than quote a few sentences from a translation of the review of the work which appeared in the JOURNAL ASIATIQUE over the signature of that eminent scholar and orientalist, Mons. Sylvain Levi of Paris. He writes :—

In his first volume, Mr. Ray has given a picture of the chemical knowledge of ancient India, which he

divides into four periods: the Ayurvedic period, from the pre-Buddhist era to about 800 A. D.; the Transitional period from 800 to 1100 A. D.; the Tantric period, from 1100 to 1300 A. D.; the intro-chemical period from 1300 to 1550 A. D. In the first period, he places Charaka, Susruta, the Bower MSS. and Vaghbhata; in the second, Vrinda and Chakrapani; in the third, *Rasarnava*; in the fourth, *Rasaratnasamuchchaya*. To this list have been added a few monographs and a collection of Sanskrit texts. The second volume may be regarded as the continuation of the first. The author has, during this interval, discovered or secured new materials, which has enabled him to throw further light upon the questions previously taken up for solution. In particular, the *Rasaratnakara* of Siddha Nagarjuna has floated before his vision as the figure of the great Buddhist philosopher who has acted so powerfully upon Indian thoughts. In this treatise on alchemy, Nagarjuna comes in as a friend of king Salivahana—a connection which has the support of an old tradition, as also his disciple, Ratnaghosa, whose name, though as yet unknown, has the probability of being a real personage. Alchemy was introduced into the sphere of Buddhism by Nagarjuna, which was almost neglected up till his time. Mr. Ray has undeniably proved, not without surprise, the grand role played by Buddhist monks in alchemy and the preponderating part of Buddhism in the Tantric literature. Even in the thirteenth century, a Hindu Chemist, named Gobinda-charya, author of *Rasasara*, declares to have composed his work "after having derived his information from Buddhist sources," as also "from the Buddhists of Tibet." Mr. Ray also notices a good many Hindu chemical Tantras and gives a summary of them, and continues the list to about the seventeenth century. The conclusion at which Mr. Ray arrives is that Indian alchemy is of indigenous origin.

The concluding words of his *History* will be ever memorable as the sombre but ennobling reflections of one of the choicest of those who "searched truth with many a sigh:—"

It is with mingled feelings that I mark the hour of my final deliverance from a self-imposed task which has occupied all my spare time during the last 15 years and more, feelings not unlike those which overpowered the Historian of the Roman Empire. The reader, I hope, will forgive me if I venture to give expression to them in the words of Edward Gibbon himself: 'I will not dissemble the first emotions of joy on the recovery of my freedom * * * But my pride was soon humbled and a sober melancholy was spread over my mind, by the idea that I had taken an everlasting leave of an old and agreeable companion.' The Hindu Nation with its glorious past and vast latent potentialities may yet look forward to a still more glorious future, and if the perusal of these lines will have the effect of stimulating my countrymen to strive for regaining their old position in the *intellectual hierarchy* of nations, I shall not have laboured in vain.

AS A TEACHER AND FOUNDER OF A
SCHOOL OF CHEMISTRY

As a teacher of young men for over a quarter of a century and having intimate association and close familiarity with a large number of students, Dr. Ray holds that the Bengali intellect is second to none in richness and fertility, though, unfortunately, it ripens rather too early and decays very prematurely. It is stated that the Bengali youth lacks the characteristic go, pluck, determination and the close application of the youths of Europe and Japan. The Bengali, according to Dr. Ray, seldom brings to bear upon anything sustained and life-long

devotion and tenacity of purpose—his enthusiasm is short-lived and is of a flashy and dashing nature.

Dr. Ray has been loved and adored by his students very much in the ancient Indian spirit. On the eve of his retirement from the Presidency College, his students presented him with an address of farewell in which they said :—

Your place in the college, sir, we are afraid, can never be filled. Men will come and men will go, but where else can we possibly expect to find again that sweetness of disposition, that vigour of simplicity, that unwearied spirit of service, that broad-based culture, that wisdom in deliberation and debate which, for the space of thirty years or more, endeared you so much to your pupils ?

Yours was, sir, indeed no small achievement. Your way of life, with its distinct Indian traits recalled us to the sweet and simple and manly days of Indian attainment. You have been to us, all through, a guide, philosopher and friend. Easy of access, ever-pleasant, ever-willing to help the poor and needy student with your counsel and your curse, living a life of sturdy, celibate simplicity, with a genuine patriotism, not loud but deep, you have been to us an ancient Guru, re-born, a light and an inspiration from the treasure-house of old Indian spirituality.

Dr. Ray has always reciprocated the love of his students, and it has been his practice for some years past to invite some of his advanced pupils to take part in his research work. As the fascination grows, these young aspirants become devoted to the cause of original

investigation and stick to the work. Year after year, their number has been increasing, till practically a school of chemists has now been established in Calcutta without any fuss or ado. We can measure the success of Dr. Ray's school when we see that the journals of Chemistry now-a-days contain rather frequent contributions of genuine merit either from him or his pupils whom he has literally trained and inspired. The May and August numbers for 1911, of the *Transactions of the Chemical Society*, London, contain simultaneously five contributions from him and his pupils. Scarcely a month elapses without some additional discoveries of his or his pupils. His own contributions up-to-date have been close upon eighty, and his work has thrown a flood of light on the chemical constitution of many of the more important compounds of nitrites. Truly, like Chevereul and Faraday, this great oriental *savant* has chosen research work in preference to money-making, and well has Professor Sylvain Levi of Paris remarked in the course of his review of the *History of Hindu Chemistry*, "that his laboratory is the

nursery from which issue forth the chemists of new India."

HIS STUDENTS AND THEIR RESEARCHES

Among those who have taken part in carrying on researches with Dr. Ray either as scholars, advanced students or voluntary workers, may be mentioned the names of Jatindranath Sen, Premchand Roychand, Scholar in Chemistry (now Professor at the Pusa Agricultural Institute); Atul Chandra Ganguli (now Professor of Chemistry, Ravenshaw College); Panchanan Neogi, Premchand Roychand, Scholar in Chemistry (now Professor of Chemistry, Rajshahi College); the late Atul Chandra Ghose, M.A., who was appointed Professor of Chemistry in the Dyal Singh College, Lahore; Hemendra Kumar Sen, who has also won the blue ribbon of the Calcutta University in Chemistry on the strength of a thesis under the new regulations; Jitendranath Raskshit, collaborator of Dr. Day in the researches on the amine nitrites, etc., Rasiklal Datta, Nilratan Dhar, Manik Lal Dey and J. C. Ghosh.

The work of Rasiklal Datta makes a record in the history of chemical science in new India. While yet a junior 5th year student, the discriminating eye of his Professor singled him out to work in co-operation with him on the subject of the benzyl and allylammonium nitrites. Within an incredibly short time, he succeeded in preparing several compounds of this series, but he found time also to make independent discoveries of his own, some of which are of surpassing interest. The discovery of a very large number of new compounds can be put to his credit.

No less brilliant have been the achievements of Nilratan Dhar in the domain of Physical Chemistry. Dr. Ray was seriously handicapped in his investigations on the nitrites for not being able to measure their electric conductivities and other physical properties. This young student almost in his teens, who had just won laurels in the B.Sc. examination, at once came forward for the relief of his teacher. Dhar's investigations on the conductivities of the nitrites as also the determination of their other physical constants

are calculated to throw much light on their constitution. The brunt of the tedious work on the determination of the vapour density of ammonium nitrite devolved on him. Dhar has also published an elaborate investigation on the constitution of complex salts, based on Werner's Theory, for publication in the ZITCHRIFT FUR UNORGANISCHE CHEMIE. In reply to an address presented to Dr. Ray by the inhabitants of his native District—Jessore-Khulna—he thus bore testimony to the quality of the contributions of young Datta and Dhar :—

As regards the numerous doubles of copper, silver, mercury, cadmium, etc, discovered by Datta, it is enough to say that I myself would have been proud to be their discoverer, but I am prouder still when I reflect that the discovery has been made by a pupil of mine. . . . I look upon it as a manifestation of Divine Grace that a Rasiklal Datta or a Nilratan Dhar has at last been produced in the soil of Bengal.

Dr. Ray has been heard to assert with some degree of confidence that Rasiklal Datta and Nilratan Dhar are fairly on the way to earning for themselves a European reputation as chemists.

Kshitishushan Bhaduri, Research Scholar, has been engaged in investigation of the active principles of some of the Indian drugs, and his labours have already

DR. P. C. RAY

been rewarded by the isolation of some glucosides, *e.g.*, of 'andrographis paniculata.' He has also prepared some interesting compounds of acetylene with copper thiosulphate.

Hemendra Kumar Sen with Biman Behary Dey, M.Sc., has, in addition to his co-partnership with Dr. Ray, described a new method of the estimation of nitrites.

An interesting method for the estimation of nitritic nitrogen by B. B. Dey and H. K. Sen depends on the use of hydrazine sulphate. When excess of the latter is allowed to act on a solution of any ionised nitrite, nitrogen, nitrous oxide and ammonia result.

* * * *

If the re-action is allowed to take place in a nitrometer, the nitrous oxide may be removed by washing with water and the residual nitrogen measured. The method has been successfully applied to some fifty nitrites, including tetramethyl ammonium nitrite and benzylamine nitrite, as well as the nitrites of the alkalis: alkali earths, and heavy metals. On the other hand, amyl nitrite, and, in general, non-ionised nitrites do not give rise to any evolution of gas when brought in contact with hydrazine sulphate.

* * * *

The action of iron and nickel on the behaviour of hydrogen with various substances has been studied by Neogi and Adhicari. The authors were unable to confirm the statement of Ramsay and Young that iron was able to bring about some union between nitrogen and hydrogen, although reduced iron as well as iron wire were tried, and at varying temperatures and different degrees of dryness.—*Annual Report for 1917*.

Hemendra Kumar Sen and Priyadarajan Ray have also studied the interaction of hydrazine-sulphate and ferricyanide of iron. The results of their researches have been published

in ZEITS. ANORG. CHEM. It was while continuing this work that Priyadarajan met with a terrible accident due to explosion of hot sulphuric acid. This young chemist who secured the first place in the M.A. examination in chemistry has already shown all the capacities that go to the making of a chemist.

Haridas Sen, an M.Sc. student, has discovered an interesting compound, "zinoso-zincic chloride." He has also prepared in co-operation with R. L. Datta a remarkable series of double sulphates of barium and heterocyclic bases.

Saratchandra Jana, M.Sc., Research Scholar, has, in collaboration with Dr. Ray, determined the vapour density of "ammonium nitrate;" the patience, diligence and manipulative skill of a high order which he is bringing to bear upon the subject speak volumes in his favour. The following extract from Dr. Ray's address on the progress of chemistry in Bengal in 1916-17 contains an account of the work done by the latest recruits of his school:—

Last year has been altogether an eventful one. It may be a little more than a year. Three Doctorates have been conferred on our students. Dr. Rasiklal Datta is the first Doctor of Science in the Calcutta University in Chemistry. It is no breach of confidence, and I am divulging no official secret when I say that in presence of our worthy Registrar (Dr. Bruhl)—I am afraid that is adding to the enormity of the crime—(laughter) one of the Referees to whom Dr. Datta's paper was submitted said that his work marked a record in Chemical researches in India. But I am placing myself under the purview of the official Secrets Act. Gentlemen, those who know Dr. Datta need not be told of the intrinsic value of his work. He has contributed some two dozen valuable papers and perhaps more. Then the Degree of Ph. D. has been conferred on Professor Panchanan Neogi. Again the Degree of D. Sc. of the London University has been conferred on Mr. Nilratan Dhar, and Dr. Bruhl had an opportunity of knowing him.

One of the most remarkable papers is that of Mr. Jnanendra Chandra Ghose. I may be allowed to say that it is a contribution which marks a new era in the subject, namely, the Abnormality of strong Electrolytes. It is a remarkable paper. This is the subject in which Van't Hoff, Arrhenius, Ostwald and many mighty workers have racked their brain. But it was left to Mr. Ghose to work out the Law which gives full explanation of the phenomenon. His first paper covers about 9 pages but it has been followed by another of 18 pages, and a third communication has also been made. These papers will throw a flood of light on one of the most interesting subjects in the domain of Physical Chemistry. To Dr. Nilratan Dhar also belongs the credit of being the pioneer in the field of Physical Chemistry in our land and of pointing out to our young enthusiastic friends the way to this fruitful line of research. Mr. Jnanendranath Mukerjee has published suggestive papers on Colloid Chemistry. Mr. Manik Lal Dey has just read a paper with experiments on a new phototropic salt. Its potentialities in the field of photography are obvious. These young scientists—the future hopes of our land—have kept up the fire

and we expect many interesting contributions from them. I am not going to tire your patience by going into details of their researches. It is not my custom to take-notice of any paper unless it has been accepted for publication in the leading Journals of Europe and America. We cannot afford to pass judgment on the work done by our own students unless it has received the stamp of the learned societies abroad.

Dr. Ray has attained fame and has rendered services to the cause of knowledge of which he and his countrymen may well be proud. But he values no part of his work more than the training of the disciples who have been attracted to him by his magnetic personality. As we have seen, some of them have very early in life, and with the limitations so numerous, won for themselves an international reputation. Like the true Guru that he is, Prof. Ray deems these young workers in the cause of Science the richest legacy to bequeath to his country and the world. He observed in a speech at Madras that, talking of his disciples, he was reminded of the Great Mother of those immortal Romans who said that her children, the two Gracchi, were her richest glory. He quotes too with an exalted humility the ancient saying of our scriptures :

Men should desire victory everywhere; but they should covet defeat at the hands of their pupils.

Mr. F. V. Fernandez, a pupil of Dr. Ray, who is also joint author with him of an important research, wrote an account of the "Indian School of Chemistry" in THE PRESIDENCY COLLEGE MAGAZINE from which we quote only the introductory and the concluding portions:—

"La chimie est une science fran^çaise. Elle fut constituée par Lavoisier, d'immortelle memoire"; thus began Wurtz his famous "Dictionary of Chemistry," and at the time when this dogmatic assertion was made, it seemed to require no word of apology from the author, so universally was the debt owed to the great master recognised by the scientific world. Yet we find that, within a few years, dissentient voices rose and darkened the halo that was surrounding the name of Lavoisier. When men were loyal to the memory of their benefactors, Lavoisier was the creator of the science of Chemistry, the reformer who taught chemists new paths of inquiry, the founder of a school of mathematical exactitude. But the searching spirit of Germany has proved to its satisfaction that the Frenchman was only a recogniser of chemical doctrine whose "great achievement consisted in abolishing old prejudices and in the masterly application of scientific principles to the explanation of chemical processes" This is about all the credit which Lavoisier gets at the present time in some of the German schools.

If such is the fate of one of the greatest masterminds of the world, what judgment can we expect from the future on the work of the Hindu *savant*, who has revived the scientific traditions of his country? He is not a Lavoisier, and yet through his efforts, the land of Nagarjuna has renewed, activities which lay dormant for centuries. It was that *savant* himself who-

bitterly deplored the "intellectual torpor and stagnation" of his country ; and there was left to him the noble task of regenerating Indian Chemistry. It is he who, to the nation of metaphysicians and visionaries has added the lustre of a school of experimental and inductive scientists. The man who has accomplished these things cannot be ignored by his countrymen. India offers the tribute of respect to her illustrious son, the founder of the Indian School of Chemistry, Professor Pratulla Chandra Ray.

Such is the history of a great scientific movement in this country. The leader has carried out his life's mission. He has founded the School. He has trained a host of chemists. And now he may rest fully assured that the work he has started will be carried on in all its details.

DR. RAY ON SOCIAL REFORM

In admiring Dr. Ray as one of the greatest scientists of the present age we ought not to forget that his life has not been lived altogether within his laboratory. Dr. Ray is a patriot, and his patriotism has the ring of sincerity which is only natural in one whose life has been a dedication to the service of knowledge and the search for truth. His contributions to Science, while enlarging the bounds of knowledge have conferred honour on his race. His work on the history of Hindu Chemistry is an undying monument to his patriotism as, through it, he has raised his country in the estimation

of the world. Besides a scholar and patriot, Dr. Ray has also been a warm social reformer. His countrymen marked their appreciation of him by voting him to preside over the Indian National Social Conference of 1917 held at Calcutta. Dr. Ray, all unconscious of how he would be misrepresented by interested political factions and only alive to the great social malady in the body politic, asked in the course of his much-discussed address :—

While the echo of *Swaraj* or Home Rule is reverberating from one end of the country to the other,—while ambitious schemes of political re-construction are being propounded by every section of the people — while gorgeous visions of a United India are capturing our imagination—loud protests of indignation are raised by classes and communities amongst us which we can no longer ignore. Why is there this note of discord where there should be only peace and harmony? Why this rift in the lute?

The answer lies in a nut-shell. It is, our failure to recognise that question which presses for solution at the present moment is as much a political as a sociological one. By the nature of things, it must be so. For however much we may try to divide and isolate the various parts of the national problem, they cling to one another as fast as ever and mock our attempts at self-deception. We cannot, with impunity, give undue preference to one over others. The law of *Karma* or causation is inexorable, and our past neglect in the work of social reform is bearing its evil fruit at the present hour. It has begun to clog the wheels of political progress.

Talking of "touchability and untouchability," he could not but speak in strong language:—

What was possible in Japan in 1871 is found to be impossible in India even towards the close of the second decade of the 20th century. Even now we find that, as the saying goes, 12 Rajputs must have 13 cooking pots and 500 Congress delegates require as many kitchen arrangements. This, at any rate, is applicable to our friends of the Southern Presidency, who have worked out the problem to metaphysical nicety inasmuch as they have added a new category or contamination by sight of the cooked food of a Brahman when seen by a member of the Panchama class even from a distance, say, by means of a telescope.

The problem of "touchableness" has assumed a scientific aspect in these days. If a Pariah crosses your threshold you throw away your jar of drinking water as polluted, but ice and lemonade manufactured by the untouchables pass current! A distinction conferred on a member of our society becomes the occasion for giving a dinner in the Town-Hall catered by Peliti, and the recognised leaders of the Hindu society take part in the function and their names are published in the morning papers, but, when on the occasion of a marriage or *Sradh* you are guilty of sitting to a feast with a Christian or Moslem or even a Hindu of the *lower* castes, you are threatened with excommunication. Reason, logic and common sense are thus scattered to the winds.

DR. RAY'S POLITICS

These views created some sensation at the time and his friends and foes thought him to be a bit reactionary in politics. His address at the Social Conference was a frank expression of the indignation which every

Indian must feel at the iniquities of our social system. But it is not fair to conclude, therefore, that Dr. Ray is inimical to the political interests now dominating the country's mind. He has himself admitted the need of some far-reaching measure of reform. If, in his address at the Social Conference, he desired to create a body of public opinion to bring about at least a mitigation of the prevalent social evils, he did not certainly mean to be a derisive influence. On the contrary, he is passionately opposed to doing anything which would impair national solidarity and has strongly deprecated the tendencies, wherever found, in the conduct of whatever party it may be, of weakening such solidarity. His remarks on Sir William Wedderburn, made at a memorial meeting held at Calcutta, are significant in this connection :—

The ultimate moral justification of England's rule over India is not *Pax-Britannica*, not even the economic prosperity of the country, but the preparation of Indian people for Self-Government. If that end is lost sight of in the pursuit of any subsidiary advantage or improvement, the British policy in India will miss its true goal. Its history will be a record of huge failure, a record of immense preparations without the fruition. Sir William knew it, and, therefore, he kept his gaze steadily fixed on the true end and aim of

England's mission in India, however distant that end might appear to his contemporaries, and he was only one of the noble bands of Englishmen who have devoted their lives to the same cause. He was "ain brither" to Henry Lawrence and Evans Bell, Henry Cotton and Allan Hume. Such lives may seem to the short-sighted materialist, to the all-wise practical politician and experienced bureaucrat on the spot as futile. But only such lives can build a bridge between East and West—only such Englishmen can make India's inclusion in the British Empire possible. When centuries have rolled away from now, when the divine purpose has wrought itself in India and the final history of our land comes to be written, the names of Wedderburn and Hume will shine in that record as a silver thread shot through the crimson web of the British conquest of India.

UNIVERSITY LECTURES

In February 1918, the Madras University invited him to deliver a course of lectures on Ancient Hindu Chemistry. Dr. Ray's addresses, it need hardly be said, were very much appreciated by his audience. It is characteristic of the selflessness of the man that, with the honorarium which the University paid to him, he endowed a prize in memory of the late Sir William Wedderburn to be awarded to the student who showed the highest capacity of scholarship or research in Chemistry. The lectures of so great and original a *savant* must have the salutary result of stimulating research in a University,

which has done so little in this very necessary direction. Dr. Ray explains the difference between the Universities of Madras and Calcutta in the matter of research in these words in an interview published in the HINDU :—

RESEARCH IN MADRAS

“ In the first place,” said Dr. Ray, “ we had in Bengal the Hindu College, latterly known as the Presidency College, staffed by Europeans and Indians, interested in research and invested with full control over well-equipped laboratory. In the second place, we have, mainly through the munificence of Sir Taraknath Palit and Dr. Sir Rash Behari Ghose, a University College of Science to which the Government of India is expected to make a handsome grant. The fact that Sir Sankaran Nair is the Education Member of the Government of India and that Sir S. P. Sinha is in charge of the Education Portfolio in Bengal leads us to feel hopeful of that measure of Government support which are warranted under the circumstances. In the third place, we Indians in Bengal have—our researchers included, who are growing in number,—a larger measure of control over education than you have here and the scope for free and unfettered development is consequently greater. Above all, public opinion, able to make itself felt, is solidly behind researchers who are growing alike in number and in importance.” “ As for Madras,” Dr. Ray continued, “ you must first of all create an atmosphere of research and this cannot be done unless you have a dozen or so of men who have secured European reputation by solid contributions to the advancement of science. If you produce more men like Mr. Ramanujam and appoint them professors of your colleges, then they will perforce be allowed to have free scope for development along lines which they themselves choose. As a first step, you might send your students to England. As regards chemistry

students, you might in the first instance send them to Calcutta. Then, as in the case of the Palit Professorships and Lectureships, you must lay down a rule that none but Indians should be appointed to high posts such as these, so that you may be sure that Indians of note, who are growing in number, shall be encouraged in their efforts to make researches with advantage to the country. Granted these conditions, strong, effective public opinion and support, and well-equipped laboratories, there is bound to be steady development." Dr. Ray spoke with feeling when he referred to qualified Indians being kept out of higher posts. He regretted that the Tatas sometime ago gave room for complaints that they did not fully encourage the appointment in their Institute of qualified Indians, but added that he believed that the mistake had been found out and matters would be improved. Our aim should be, he said, to create a set of qualified, self-reliant scientists and this could not be done unless we give opportunities of training for our promising youths."

HIS METHOD OF STUDY AND WORK

The question may arise: how a confirmed invalid or valetudinarian has been able to do so much in so many different spheres of activity. The answer lies in a nutshell—Dr. Ray believes in doing one thing at a time and doing that well—he has been heard to say that it is concentration of mind that pays and not the number of hours devoted to study—he cannot read more than one hour at a stretch and that in the morning as his brain gets easily fatigued—but he is an embodiment of order, method and punctuality. Dr.

'Ray's appetite for chemical researches simply grows by what it feeds upon : he is author or joint-author with his pupils of some eighty contributions chiefly on the nitrites and it was in the fitness of things that Prof. Armstrong should style him "Master of Nitrites." Since joining the College of Science, he has communicated to the Chemical Society of London a number of papers revealing some striking results of his researches in Chemical Science. India's work at the Laboratory is his supreme delight and so long as he is inside his *sanctum* he forgets all about the outside world.

We have in these pages dealt at length with Dr. Ray's chemical researches as it is primarily on them that his place in the world of science will ultimately rest secure. Indeed, his name is undoubtedly linked up with that of Sir J. C. Bose as a distinguished scientist in an epoch distinguished in many branches of learning. As the doyen of the Calcutta University and the founder of the Indian Institute of Science he has done meritorious service in the realm of Chemistry and allied sciences.

Nor is his reputation unknown abroad: for more than one University in Europe has honoured itself by showering on him its academic honours. In India itself, he was appointed again and again to the Professorship of the Palit Trust "in the interest of Chemistry."

INDIAN SCIENCE CONGRESS

Presiding over the Indian Science Congress in February 1920 he abjured the youth of the country to cultivate the scientific habit of thought—not to take anything on trust but to pursue truth with the light of reason and pursue it diligently and persistently. He said :

While the study of science is essential to our material advancement it has a special need and significance for the culture of Indian youth. A long period of intellectual stagnation, has produced in us a habit of dependence on the authority of the Shastras. Reason was bound to the wheel of faith and all reasoning proceeded on assumption and premises which it was not open to anybody to call in question or criticise. Intellectual progress was handicapped under these conditions and it is no wonder that India cannot point to any notable achievement in this line during the 1000 years that preceded the advent of British Rule. Reason has thus to be set free from the shackles and the function of science in achieving this end is indisputable. Science takes nothing on trust but applies to them all the methods of investigation and criticism. I look forward to the growth of this scientific spirit in our country to liberalise our intellect. There is no lack of capacity amongst our young men.

what are wanted are patience and tenacity of purpose. Science, as Huxley said, requires the virtue of self-surrender. You must patiently observe and interpret the phenomena and events. There is no room for a prior reasoning in the realm of science.

A GREAT HUMANITARIAN

But apart from his eminent services to Chemistry Dr. Ray has been no less interested in other spheres of public work. We have referred to the burning patriotism of his youthful days which has in no way abated in his old age. Indeed he has grown more and more enthusiastic in public service as age advances. And many have wondered at his marvellous energy and no less marvellous enthusiasm for many a cause. And yet his love for science is so absorbing that he would not give up chemistry for politics. Asked to stand for election to the reformed Legislative Council in August 1920 the distinguished chemist replied to an interviewer :

When there would be 30 chemists in India I will consent to give up my work and enter politics. . . . There are too many politicians in India already more than we know what to do with — but chemists are sadly needed in this country more than even politicians. We have not enough chemists. I am deeply interested in politics. I would like to pin the new Hindu widow marriage movement which you have so nobly encouraged. I would like to do many other things. I am interested in so many directions but

every fraction of a second I give to other things is so much robbed from chemistry—and my work suffers.

A GREAT HUMANITARIAN

Yet the love of social work is great to humanitarian spirits like Sir P. C. Ray. During the disastrous famine in Khulna none laboured more hard, none dared so greatly as the old chemist. He went to Khulna, inspected the area, and set to work among the rescuers with the buoyancy of youth. Day after day he devoted to the ministering of the famished poor and spared no pains to alleviate their lot. It was there also that he came to realise the great potency of Khadi of which he became such a stalwart advocate, since then. The success of his experiments with the charka in famished Khulna proved to him the wisdom of Mahatma Gandhi's devotion to the spinning wheel and his great faith in its economic value.

THE CHARKA

But to realise the value of the charka is for Dr. Ray to throw himself heart and soul into the movement. He could do nothing half-hearted. And he is to-day second to none in

his enthusiasm for the spinning wheel. Indeed besides actual work among the peasants of Bengal and Assam, he has spoken to innumerable audiences all over India on the virtues of this great yet simple instrument of rural reconstruction. Recounting his experience of the Charka in famine areas Dr. Ray said at the Seva Sadan Samity in October 1921 :

Now the population of Bengal is about 45 millions or $4\frac{1}{2}$ crores. Even if we have out of consideration $3\frac{1}{2}$ crores and pin our fate on one crore of able and willing workers (men and women), and if they earn only half-anna per day by spinning or Re. 1 per month, this would yield us one crore per month or twelve crores of rupees-earning per year. There is no reason, however, why one should not earn Rs. 2 per month in the above manner. This would add twenty-four crores of rupees to the income of the people. Political Economy tells us that one should not waste his time more profitably. But here you have to deal with a people who are notorious for their indolence and who have no alternative occupation or industry to fall back upon in times of such dire distress. And I am of opinion that the 'Charka' should prove the salvation of such people.

Such are the economics of the spinning wheel : and no wonder that with this conviction of the potency of the charka Dr. Ray shares all the enthusiasm of Mahatma Gandhi himself in his exposition of the cult of the Charka.

In fact next to Mahatma Gandhi himself there is none so thoroughly devoted to khaddar, with such mastery over the details of khadi production, or so completely inspired by it as Dr. Ray. He is even more eloquent and illuminating on the charka than on the chemical sciences in which he has won such universal distinction. Speaking at the Khaddar Exhibition in Cocanada in Dec. 1924 Dr. Ray pointed out that apart from spinning being a supplementary source of income to the peasant it is also the means of stimulating a host of other village industries :

When an entire village takes to Charka, the weaving-loom also becomes brisk ; side by side, the dyer, the carpenter also find occupation. In fact, spinning may be regarded as the key industry of village life, the only home-industry *par excellence* and it goes far towards making the village self-contained in the matter of our indispensable requirements. The spirit of enterprise, and briskness and self-reliance that such an organisation connotes would soon bring new life into our village, and would prevent them from falling into the decay that is at present gradually overtaking them.

The economic value of the universal adoption of Khadi is well illustrated :

Taking the population of India to be roughly thirty-two crores, the total income, according to Lord Curzon's computation, would amount to nine hundred and sixty crores of rupees per year. Now if only one fourth of the population would spin 2 hours daily, then the national annual

income will be increased by ninety crores. This is on account of spinning alone without taking into consideration the increase due to weaving this yarn and also the additional income accruing to other professions, the carpenters and smiths, for supplying the accessories. And as a mere element in this stupendous whole, the annual drain abroad of sixty to seventy crores of rupees on the score of piece-goods would stop and would remain in our country to enrich and nourish the life-blood of our half-starved peasantry.

And then he tackles the question of distribution, which is no less important than production. Dr. Ray wisely observes that this work of distribution is automatically done by the adoption of the Charka:

No amount of human ingenuity can manage to distribute water over the whole land as a shower of rain can. No irrigation department, no rules of precedence, no inspection, and no water cess. Everything is done with an ease and gentleness that by their very perfection evaded notice. The spinning wheel, too, has got the same power of distributing work and wealth in millions of houses in the simplest way imaginable.

HINDU-MUSLIM UNITY

Dr. Ray carries the spirit of research into every branch of study. Early in life that spirit expressed itself in his interpretation of certain transactions in British Indian history. Presiding over the convocation of the Aligarh National University in March 1923 Dr. Ray gave a bit of Muslim history in India which is full of lessons to us

in these days of Hindu-Muslim controversies. He showed that the Hindu-Muslim fraternity is not a thing of yesterday but dates back from the days of the Pathan rule. Indeed the history of the progress of Islam in India is the history of the Hindu-Muslim collaboration.

Some of the greatest generals, greatest financiers, greatest ministers of the Muslim Kings and Emperors were Hindus. Those were not the days when what was conceded in principle was denied in practice. After a century and a half of British rule in India we were in ecstasies, why sooth because a solitary Lord Sinha was installed on the gadi of an Indian Province; but how many such Sinhas: Man Sinha, Jasovanta Sinha, Jai Sinha, to mention only a few, were trusted with positions far more exalted and far more onerous?

This Hindu-Muslim unity, this fusion in the ideas, the sentiments, the traditions of the two great races of India, has not merely been confined to politics; it has filtered down to the inmost recesses of the social structure, and has led to various social and religious reactions. Guru Nanak, Kabir, Chaitanya—these were all the exponents of a religious movements due to the interaction of the two cultures. Perhaps it may appear strange that a Muslim King of Bengal, Hussein Shah, should be addressed like this. "Be thou immortal, O Lord of the Five Gours," by Vidyapati, the foremost of the Bengalee Vaishnava poets. But all this was a sign of the times. The democratic spirit of Islam exerted a very healthy influence in breaking down the age-long evils of the Hindu caste system and infusing a catholic and enlightened spirit into the Hindu society itself. And the Vaishnava movement of Bengal was the direct outcome of the renaissance. Even to this day this mutual acceptance is so complete that the Hindus do not feel any hesitation in adopting the holy shrines of Muslim, the dargas of the Pirs as their own sacred places, and going on.

pilgrimage there: nor do the Muslims hesitate to take part in the social festivities which are so happy a feature of the Pujahs of the Hindus.

SOCIAL REFORM

Dr. Ray has been a social reformer all his life both by precept and by example. Welcoming the delegates to the Hindu Maha-Sabha at Calcutta in April 1925 Dr. Ray exhorted the Sabha to confine its activities to the reform of internal abuses and to the consolidation of the different sections and castes of the Hindu society. He similarly advised the Muslims, Christians, Sikhs and others to have their own organizations and pursue their work of reform from within and to work with other communities in a broad liberal spirit, without hindering the growth of a united India.

A house divided against itself can not stand. Hinduism has now degenerated into a hardened, nay petrified conglomerate of unmeaning and often obnoxious social customs. I appeal to our Hindu brethren to ponder over these serious problems, there is civil war in Hindu community—the Brahmin and the non-Brahmin arrayed against each other and the Panchama against the Brahmin and the non-Brahmin combined. Two thousand years ago *Aesop* foresaw the mischief and depicted it in his famous parable of the non-co-operation of the belly and other members of the body. How can we attain our political emancipation so long as we have all these warring elements amongst ourselves. It will not be possible for us to assert our

political rights at home or abroad when we are not prepared to concede the fundamental rights of humanity to our own brethren our own kith and kin.

ADDRESS TO THE MYSORE UNIVERSITY

In November 1926 Sir P.C. Ray was invited to deliver the convocation address to the new graduates of the Mysore University. Dr. Ray has always something striking and fresh to say to the students and in this address he pointed out that the problem of education, here or elsewhere had not been handled with that intelligence and sagacity which it deserved. He spoke on the causes of intellectual sterility in India :

If we begin by critically examining our methods in India, the first outrage that we find committed was in making a foreign language our vehicle of instruction. It is surprising that this principal reason for our intellectual sterility was not discovered till very recently and it is more surprising to find that some of the well-known educationists of the time continue to regard this relegation of the English language to an inferior position as fraught with disastrous consequences!

He showed what colossal waste of national intelligence we had allowed in the past by our scheme of university education, and how unqualified for the practical matters of life we emerged out of this machinery.

The two universities of Calcutta and Madras, have become two huge factories for mass production of graduates ! This inordinate, insane craze—almost

a mania—for securing a degree has been working infinite mischief—it has become almost a canker eating into the very vitals of intellectual life and progress.

A year hence, that is in December 1927, Dr. Ray discussed the same question from different points of view in the pages of THE INDIAN REVIEW. He criticised our craze for Western ideas in education and deplored that the modern young educated man is making a laughing stock of the world, drifting he knows not whither. He pitied the poor parents whose substance is wasted in giving their sons a veneer of pseudo-education ill-suited to the needs of the country and utterly useless as a means of earning even their livelihood. He drew a very pathetic but true picture of the modern college-bred, hostel-fed, youths ignorant alike of our Vedic heritage and the practical knowledge of arts and crafts.

If one is to ask what is the prospect of a graduate of one of our Universities I should say almost nil. The plight of an Indian graduate of the Badralog class (gentle folks) is pitiable indeed, starvation staring him in the face. The professions are over-congested and yet they are swelling the ranks.

The college-bred youths fight shy of entering any trade or taking part in commercial pursuit. Once he has crossed the threshold of the College, he is done for. He wants soft jobs and rusts away all his life on a bare pittance. Oh! the tragedy!

The educated young man is also reluctant to go back to his ancestral home in the village as he has lost all touch with his own kith and kin. He cannot accommodate himself to the amenities of rural life, because he sycophantly mimics the European costly mode of life. This hybrid production—the educated young man—is making himself a laughing-stock.*

The educated man cannot strike a path of his own. He must move in the fixed groove though his head is crammed, full of Shakespeare and Milton, Spencer and Mill, and this in the land which once produced a Sankara or a Ramanuja.

It is time we cried "halt" and adopted a mode of life in harmony with our incomes and traditions.

THE CHARKA AGAIN

Dr. Ray again and again reverts to his favourite charka, whether addressing students or laymen. So inspired is he by the music of the spinning wheel and so bored by the facile criticisms of fashionable people that he expressed himself severely to a Press representative in Bombay in December 1928. Summarising his faith in Khadi he observed :—

I am as firm a believer in the charka as ever. There are 84 mills in Bombay, and nearly as many in Ahmedabad. The number of labourers employed in the mill industry in these two cities will be between 300 and 400 lakhs. Again, there are 84 jute mills on the banks of the Hughli and a number of mills in Cawnpore and other places too. I believe altogether there are a million and half workers employed in mills all over the country.

I am sick of the futile criticism of arm chair politicians and their gossips under the electric "punkah." For Heaven's sake, do something practical and show by

actual proof that you have a better substitute for the charka, which can be introduced in the millions of rural homesteads. These gentlemen forget that India is not England, Sweden or any other European country. Here, we have unlimited and inexhaustible man-power lying absolutely idle during, on an average, five or six months in the year. How are you going to urbanise these teeming millions and transfer them to so many Bombays, Calcuttas and other cities ?

HIS CHARITY

Much has been written of Dr. Ray's achievements in chemical science, of his tireless labours on behalf of the country in more than one field of beneficent service. We must say a word of himself, apart from his character as chemist, or politician or reformer.

Mr. Padmini Mohan Neogi, writing of him in the INDIAN WORLD, speaks of his philanthropy in these feeling words :—

We who have had occasions to know the influences that are working upon young Bengal, can make bold to anticipate that his goodness, his charity and inspiration if nothing else, will ever be a household topic from the centre of the metropolis to the distant corners of Bengal where the benign torch of education has been carried. Uneventful as his life has been, free from the bustle of the pompous follies of society, single in his life, his is yet an eventful life—events not like the passing of a bill in a legislature, or the foundation of a memorial institute, or a bountiful donation for a Rai Bahadurship, but simple tears of orphans, of aspirant but indigent youngmen, of the high or the low or the warfare of an acid with a metal or the friendship of an acid with a base. How often have we seen wretched youngmen, wretched on account of

poverty, going up into his laboratory room where they laid bare their heavy bosoms, and he the father of them all, fondling with all the affection as though they were his own. We have heard him say many a time and oft that poverty is a rigid school and the sessions are long and bitter; but the men and women who graduate therein come forth with physical frames capable of enduring fatigues, with hearts habituated to disappointments, and fortified against the rebuffs of fortune, with intellects trained by patient, laborious and unbending application. What an intolerable chain it binds around aspirant souls? And yet the world's greatest thinkers have felt this iron in their flesh and bursting the galling bonds, have carved their way to eminence and immortality. Though himself a prodigious man of charity (for which his friends have sometimes taken him to task), his opinion regarding money-saving has been but simple. Of all charities, he often says, mere-money-giving is the least; sympathy, kind words, gentle judgments, a friendly pressure of weary hands, an encouraging smile will frequently outweigh a mint of coin. Bear this in mind, we have often heard him say, selfishness is the real root of all the evil in the world; people are too isolated, too much wrapped up in their individual rights, interests and enjoyments. The first person singular is the God of the Age.

CHARACTERISTICS

Severely simple and ascetic in disposition, Dr. Ray has given the best part of his life to build up character among his students and inspire them with the love of knowledge for its own sake. He may have had his disappointments, but he has done more to inculcate the wisdom of plain living and high thinking than perhaps any other man now living in Bengal. A few racks of books, a miserable-

looking and antiquated bedstead, an eighteenth-century table, with a few old-fashioned chairs form all his earthly belongings; and though he had been to England thrice, he had acquired none of the arts of grace and fashion of modern life. His dress is simple and his personal appearance seems so-neglected. It has been often embarrassing to his visitors to recognise the man whose greatness had induced them to catch a glimpse of him. The striking sketch of him by Mukul Chandra De is a marvellous pictorial reproduction of the unpretentious scientist with eyes seeing deep into truth through all the veils of illusion and concealment.

Dr. Ray, having been single all his life, has not had many charges on his purse and no serious financial obligations to discharge. Almost all that he earns as a professor or as profits from the Bengal Chemical and Pharmaceutical Works, he spends on poor boys, deserving institutions and charities. It is difficult to spot out many poor boys, in the Calcutta colleges who do not receive some help or other from this philanthropic professor

and there are very few deserving charities in Bengal that do not count him as their patron. Indeed, behind an unpretentious and attenuated figure—Dr. Ray has been a confirmed dyspeptic for over 55 years—he carries a heart as warm as the climate of his native land.

Absolutely Oriental in habits and tastes, there are very few men in Bengal who have drunk so deep of Western knowledge and who have been so strong and steadfast champions of right thinking and right doing. A devoted and careful student of Mill and Spencer, Dr. Ray is a rationalist to the very core of his heart. He seldom allows his emotions or the prejudices of his environment to get the better of his judgment. He does not believe in caste or communal ideas and, though a member of the Brahmo Samaj, is far from thinking that that church can claim any monopoly of any moral and spiritual wisdom. He hits as hard in private life against Hindu practices as against Brahmo pretensions. Some years ago he contributed to a vernacular periodical of Bengal an article in which he

boldly came out with chapter and verse to prove how the Bengali intellect, or, for the matter of that, Indian intellect, had suffered through foolish customs and absurd religious prejudices.*

NATURE'S GENTLEMAN

Prafulla Chandra Ray is not only one of Bengal's greatest sons but is also one of Nature's truest gentlemen—every inch of him. Though a man of very strong convictions, he has hardly made an enemy in his life. He is an embodiment of Matthew Arnold's culture and sweet reasonableness. He cherishes no jealousy, entertains no malice. Even when he differs from anybody, he imputes no motives nor attempts to throw any mud at his opponents. He is frankness and cordiality almost to everybody, and never plays with any cards in his sleeves. When he fights, he fights with gloves off. In all his private and public dealings, he is most scrupulously honest and above board. He believes

*For full text of the article see "Essays and Discourses" of Dr. P. C. Ray. Rs. 3. G. A. Natesan & Co. Madras.

in a clean and pure life and has himself lived up to this ideal. Sparing as an eater, a speaker and correspondent, he has not allowed many distractions to disturb the even tenor and equanimity of his life. The work in the laboratory is certainly the most fascinating and engrossing work of Dr. Ray's life, but, besides a scholar and savant, he has also many social attractions. He has a warm corner in his heart for many friends to whose homes he pays regular visits and with whom he always keeps himself in intimate touch. Not very infrequently, he goes about begging from the house of one such friend or other for either half a piece of a cake or some home-made sweets or some other delicacies, and the ladies of those houses take a special delight in providing him with "good-grub." Among others, with whom he has maintained life-long friendship and in whose homes he is always received with open arms, may be mentioned the names of Sir J. C. Bose, Dr. Nilratan Sircar and others. There is another set of friends with whom he makes a point of passing about three hours every evening in the

spacious maidan flanking Chowringhee Road (Calcutta). Being almost a lifelong victim to dyspepsia and a bad nervous system and being troubled with insomnia now and then, Dr. Ray has found life and health and recreation in the religious observance of this evening programme. Every evening, in cold and heat, in rain and summer, Dr. Ray is found squatted on the grass of a quiet corner in the maidan with a number of friends agreeably occupied in the pleasant pastime of " chronicling small beer."

CONCLUSION

Dr. Ray will rank in history as one of the greatest of those who have helped in building up the edifice of modern India. His name stands along with those of Sir J. C. Bose and Sir C. V. Raman as evidence of the genius of the Indian mind for scientific research. It is the most hopeful sign of our renaissance that it is not confined to one or two aspects of life only but is universal and all embracing. The wave of new life has pervaded every nerve, vein and muscle of the national being. On the side of Science and Research,

the achievements of P. C. Ray, J. C. Bøse and C. V. Raman represent the high water-mark of the national genius. Others have achieved eminence in other fields. But to these belong, in a special measure, the honour of living up in a materialistic age to the grand ideal expressed in the words of one of them :—

Not in matter, but in thought, not in possession or even in attainments but in ideals are to be found the seed of immortality. Not through material acquisition but in generous diffusion of ideas and ideals can the true empire of humanity be established.

SIR C. V. RAMAN

PROF. C. V. Raman, who was knighted on the King's birthday (3rd June 1929) for his eminence in Science, was born of humble parentage on the 7th November 1888 at Trichinopoly in Southern India. His father, Chandrasekhara Iyer, was a teacher in a local institution. Soon after the birth of Raman, the father had an offer from the Principal of Mrs. A. V. N. College at Waltair, which he readily accepted. The journey from Trichinopoly to Waltair was not an easy thing in those days of travel by country-cart. The incident, we are told, brought out in vivid relief the courage of the father and the devotion and persistence of the mother—characteristics which Mr. Raman has inherited in no negligible degree, and which have stood him in good stead in his long and steady pursuit of science.

Mr. Chandrasekhara Iyer was Professor of Mathematics and Physics. He was a man

of varied tastes. Mathematics and Physics are so closely allied in the higher stages of their study that they almost merge into each other. Prof. Chandrasekhar had equal proficiency in both the subjects. He had also studied Astronomy with great interest. He was also a lover of music. This was indeed the result of his family connections. He was related to Pandit Vaidyanatha Sastry, the great Violinist of South India. His interest has also descended to his son. The great researches of Dr. Raman in the field of Acoustics and especially among the musical instruments of the Violin family, are indeed traceable to his father's love of the Violin.

Raman proved himself a precocious child. Whether by inheritance or by sheer instinct, he exhibited an aptitude for science, remarkable for one of his age.

EARLY INFLUENCES

Though the circumstances of his early life were conducive to scientific training, Raman was utterly apathetic to religion. His parents were by no means very orthodox, and no wonder he was indifferent too. But the

trumpet voice of Dr. Besant who was just then at the height of her influence over Hindu Society, soon won him over to religion and reform. Raman was now twelve years old. Religion was as yet something strange to him. It is no wonder then that the message of Dr. Besant made a profound impression on the impressionable mind of the thoughtful youth and came to him as a sudden revelation.

The impression was so strong and deep as to suppress for a time even his natural ardour for scientific study. He was irresistibly drawn into the general whirl of religious zeal. He fell heart and soul into the study of religious literature. The study of Physics gave place to the study of the Ramayana. The Mahabharata usurped the place of the scientific apparatus. Raman never did anything half-heartedly. He put his heart into everything he undertook. His study of these religious books was so zealous, so intelligent, so deep, and so thorough that when, in the B. A. class at the Madras Presidency College, he had to write an essay on Epic Poetry, he chose the Indian Epics, and his essay won the first prize. But his religious

zeal was short-lived. His scientific ardour was inborn. He was a born scientist. The study of our sacred literature was the result of a passing wave of religious enthusiasm. Nature soon re-asserted her sovereignty, and scientific study was resumed with renewed vigour.

AT THE PRESIDENCY COLLEGE

In the year 1901, when the usual sessions of the Madras Presidency College commenced, Prof. E. H. Elliot came into the combined section of the B.A., class to teach English Poetry. He observed among his new students a bright-eyed little lad who could not possibly be expected to belong to that class. He was so short, slim and small. "Do you belong to this class?" asked the Professor. A loud and boisterous laugh greeted the question from the galleries.

"Yes Sir, I do," was the reply.

"What is your age?"

"Thirteen."

"Where did you study for your F. A. Examination?"

"At Waltair."

"Your name?"

"C. V. Raman."

The bold and ready replies combined with the interest evoked by his extreme smallness, went home to the heart of the interrogator; Raman ever afterwards remained the pet of the English Professor.

Raman was strongly advised by a near relative and well-wisher of his family to choose History as his special subject, as it would greatly help him in the Competitive Examination for the Superior Services in the Provincial Government. It was urged that there was no Government servant in the family and that "Venkatram should be one." "No" was the positive answer of the precocious lad. He would choose that subject which he liked most, and for which he had the keenest aptitude.

Raman soon became an object of special love and attention to all his professors. He had left his philosophical studies to take care of themselves, and his religion did not interfere with the serious study of the Sciences. He was a very fast reader. Even to this day, he has retained this habit. If a slight fever or any indisposition should confine him to

his bed, he would take up a novel of some modern author, and read through his four or five hundred pages in a couple of days. He had closely acquainted himself with the standard writings of the great authors on his subject; and, with great ambition, hoped to make his own experiments in the College laboratory. His Professor did not permit him to do any extra practical work in the laboratory. But soon an occasion offered itself for the display of his scientific genius.

BEGINNING OF HIS SCIENTIFIC CAREER

The first epoch of Mr. Raman's scientific career began. He had passed the B. A. Examination in the first class and won the Arni Gold Medal in Physics. He was now in the M. A. class with Physics as the subject of his study. One day Mr. V. Appa Rao, a friend and class-fellow, came upon some anomalous observations while performing some acoustical experiments, and he referred them to Prof. Jones, who seemed at his wits' end, how to explain and account for them. The genius of Mr. Raman comprehended the whole arrangement at one flash.

He performed the experiment himself, and after going home, read once more through Lord Raleigh's theory of sound and made out a calculation to his best satisfaction. It was a new arrangement to perform Melde's Experiments. Mr. Raman was thoroughly convinced that "when properly performed, its results easily surpass, in beauty and interest, those obtained by the usual arrangements in Melde's Experiments." The modified form of Experiment suggested by Mr. Raman has since commended itself to all thinkers in the scientific world. Lord Raleigh himself has not been slow in congratulating Dr. Raman, and he sent him a letter appreciating the scientific value of the suggested modification. With the energy and optimism of youth, Dr. Raman at once wrote out a memoir of his investigations and presented it to Prof. Jones who promised to look it over. It was past one month, two months and three. The youthful scientist asked for his paper; the Professor was still looking it through. So, another quarter rolled on and Mr. Jones had not finished the

perusal of the memoir. The impatience of the young researcher was great. The Professor was too slow a reader. At last, Mr. Raman tactfully managed to get back the memoir under pretext of re-writing it. When he got the paper ready for publication, he sent it at once to the Editor of THE PHILOSOPHICAL MAGAZINE, London, without informing Prof. Jones about it. And it was not long before Mr. Raman received the proof-sheets of his article. He was then a boy in his teens ! His own heart beat with joy. He ran with the proof-sheets to his Professor. Mr. Jones read through the article (now quicker than before), and seemed half-pleased and half-annoyed. "Why did you not show it to me before you sent it up ?" he asked in a passionate tone. Mr. Raman replied, "I thought you had read it through, and had no corrections to make. I am sorry." The professor was satisfied or rather seemed so. How complex is human psychology ! How varied are the main-springs of human passion !

During the last year of his stay in the Madras Presidency College, Mr. Raman had

published another original paper in that popular journal of natural philosophy called *NATURE*, which is also issued from London. This time it was not Acoustics but Optics. The subject was, "Unsymmetrical Diffraction-Bands due to a Rectangular Aperture." The field in which Dr. Raman was to carry on his researches was clearly marked out for him even in his college-days. The two *memoirs* which he had published as a student in the Madras Presidency College, were but the beginning of a huge mass of literature which was to follow in succeeding years, descriptive of his investigations in the self-same field of Optics and Acoustics. Certainly, if any great scientist fell into the proper track from the very beginning, it was Dr. Raman.

IN GOVERNMENT SERVICE

Raman had thus a brilliant career at College. When he got through his M.A. in the Presidency College, no time was lost on the part of the Educational authorities at Madras to approach the Government, which readily came forward in deference to the strong recommendation of Prof. Jones, to afford the

necessary facilities for a European training, to Mr. Raman. Only one thing remained before the young scientist could sail for Europe. That was the certificate of physical fitness. Dr. Raman was naturally lean and feeble. His frail frame was in striking contrast to his strong and energetic intellect. It was feared that he might collapse under the strain of a sudden climatic change. He was examined by an English I. M. S. Officer of the Madras Government, and was found to be too weak to bear the incident dislocations of a change of climate. Hence the idea had to be abandoned. Dr. Raman was not to sail for England.

The prospect of going to Europe, having vanished, Mr. Raman looked out for a career in India. Neither teaching nor law had any attraction for him. He was too deeply absorbed in his scientific studies to be swayed by considerations of social or pecuniary advantage : and science is a jealous mistress.

So, there was only one alternative. That was the only alternative to every intelligent young Indian who set his eyes away from the

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SIR C. V. RAMAN.

professions of the Lawyer and the Teacher. The All-India Finance Department afforded what were considered, and are even to-day looked upon, as brilliant prospects for any young man. Mr. Raman was advised on all sides to become a candidate for the Competitive Examination. He had just appeared at the M. A. Examination of the University of Madras. Immediately after, he was asked to appear at the Competitive Examination for Superior Service in the All-India Finance Department. The Examination was conducted by the Government of India. Mr. Raman's nomination for the examination was arranged by Prof. Jones, through the Madras University. So the young nominee came to Calcutta to appear for the examination. He had to study quite unfamiliar subjects. History, Mr. Raman never liked from the very beginning. He had to study Political Economy and Sanskrit too. It was indeed a hard task. He was patiently plodding through his subject and did not quite hope to be ready for the examination, at such a short notice.

Just before the day of the commencement of the examination, he received a telegraphic message from Madras that he had not only stood first in the whole University in the M.A. Examination in Physics but that he had passed in the First class. He was the first First Class M. A. in Physics in the whole annals of the University of Madras. This unique recognition of his genius, this brilliant result could not but have a beneficent effect on his other activities. It fired him with an enthusiasm to become worthy of such an honour by as equal a success in the Finance Examination.

He was not less successful in the Competitive Examination than in the M. A. Examination. He stood first in the whole country. He was still young. A lad who had just passed his middle teens! He won the distinction of being the best among the candidates. He was at once appointed as a Deputy Accountant-General of the Finance Department of the Government of India. He belonged now to the Indian Imperial Service. He became a Gazetted Officer of the Indian Government.

'Eighteen years old! Already an officer in a responsible branch of the Indian Administration! Cardinal Wolsey was called a Boy-Graduate. Certainly, Dr. Raman was a Boy-Officer. There has never been a second in this country who had attained to such a distinction at such an early age.

RAMAN'S MARRIAGE

Mr. Raman was now above want. But he was faced with the stern realities of life. Till now he was a boy. He was now to take up the duties of manhood. His wife was the favourite daughter in an opulent family of Southern India. She was the daughter of the late Mr. S. Krishnaswamy Iyer, Superintendent of Sea-Customs at Madras. Her mother, Rukmini Ammal, saw the brilliant young "Venkatraman" and felt a presentiment that he was her destined son-in-law. But he belonged to a different sub-sect of the Brahmin caste. The marriage would be contrary to custom. The father of the bride was not quite anxious for the alliance. Perhaps the fact that Mr. Raman was not rich had something to do with this attitude. But there was another

reason for his conduct. Though a man of liberal views in his private life, he was extremely conservative on ceremonial occasions. He was not prepared to break sacred customs and time-honoured usages. He was not anxious "to create whirlpools in calm waters." But the bride cut the Gordian knot! She preferred genius in rags to stupidity in purple. The marriage was celebrated at Madras. It was somewhat of a sensational event in those days. The most orthodox stood aloof. The late Justice Subrahmanya Iyer and Justice Sadasiva Iyer graced the occasion with their presence and eulogised the moral courage of the parties concerned. It was considered as a triumph of good sense and rationalism over the forces of blind prejudice and meaningless custom. The Theosophists looked upon it as a success to themselves. The marriage was the first of its kind in Southern India. Miss Triloka Sundari became Mrs. Raman and the young man was soon to take up the duties of a householder.

His unprecedented success in the M.A. Examination was his first triumph; the result

of the Competitive Examination recorded the second ; his marriage marked the third. This triple triumph marks the close of his educational course and the beginning of his official career.

AT CALCUTTA

Mr. Raman was appointed as an officer in the Indian Finance Department of the Government of India. His designation was "Deputy Accountant-General." His official career may be divided into various periods each of which is remarkable for some notable event which was closely connected with his scientific activity and which furthered the progress of his scientific thought. His official life began at Calcutta where he stayed for nearly three years. The responsibilities of office could not alter the natural bent of his mind. He had brilliant prospects in his official career. A lesser man would have left science to take care of itself. But Raman did not neglect his special mission even in circumstances apparently adverse to scientific pursuit.

His joy knew no bounds when one day, while he was going from Dalhousie Square to

Sealdah (where he was then putting up), he caught sight of a sign-board with the inscription: "The Indian Association for the Cultivation of Science." He saw, he looked, he wondered. Was it a reality or a mere dream? Is there any such Association in India? said he to himself. Not a minute was lost. Down he jumped from the tram-car, and soon found himself in the midst of the members who had assembled there for a meeting and were just dispersing. Sir Asutosh Mookerjee too was there. Many great notabilities of Calcutta, who evinced any interest in science, were to be found there. Mr. Raman was directed to the Honorary Secretary, Dr. Amirtalal Sircar, the son of the great Mahendralal Sircar, who had given a life-time to popularize the idea of scientific education in this country. Mr. Raman made an appointment with the Honorary Secretary to meet him at a convenient time the next day. Then he showed him his former publications in European Journals of Science and pointed out that there was much to be done in the subject. Dr. Sircar was struck with the orginality of the young scientist, and

at once proposed to afford every convenience for the proper carrying on of Research work by Mr. Raman. The latter became a member without any further delay. His previous career was appreciated and admired by all. He was accorded special facilities. A mere accident became an important incident. His heart-hunger was satisfied. His long-felt want was supplied. He fell heart and soul into his proper sphere of activity. Thus began Mr Raman's connection with the Indian Science Association, which was providential though accidental, and which had a profound influence not only on the career of Mr. Raman himself but on that of the Association as well. Thus began his acquaintance with the Vice-Chancellor of the University of Calcutta, which, in due course, brought them into closer touch which increased their mutual friendship, appreciation and admiration, and finally changed the whole course of Mr. Raman's life in after years.

Mr. Raman wanted a laboratory. The laboratory of the Association wanted a great scientist. Mr. Raman and the Indian Science Association had long wanted each other badly.

They suddenly met, joined hands and became united. The union was fraught with great possibilities. Its immediate effect was the commencement of real scientific research work in the Association. It was destined to vindicate the scientific greatness of India. The achievements of Indian Science have now acquired world-wide reputation. The Indian Association has spread its fame throughout the world.

Mr. Raman was now himself again. Nothing now stood between him and Science. His whole leisure was now dedicated to the idol of his heart. The results of his research were published in the form of Bulletins through the Association. But this vigorous work was not long to continue. It was only three years that Raman could spend in Calcutta. During the period, he had established his reputation in Calcutta. His great genius, wonderful energy, and constant application to his work with single-hearted devotion became a topic of common talk with persons interested in scientific studies. The late Sir Gurudas Banerjee took an active

interest in Mr. Raman's work in the laboratory of the Association.

While such were the happy circumstances in which Mr. Raman was placed, he was suddenly transferred to Rangoon. The transfer deprived the Science Association of Mr. Raman's service for a time. But the seed had already been sown, and it was bound to bear fruit in the long run. Mr. Raman left Calcutta with a heavy heart.

IN RANGOON

A characteristic incident is recorded of Mr. Raman's early days in Burma, how, after only a couple of days' stay in Rangoon, he marched out on an expedition to a neighbouring station at dead of night (leaving his wife in desperate loneliness) to see certain new scientific instruments that had arrived at the laboratory of the Insein School, and returned home in the early hours of the morning. The incident is significant of the lure of science to men of Mr. Raman's single-minded devotion to it. For the rest, the young officer carried on his work in the usual course, exhibiting the same spirit of courage and steadfastness. The Ac-

countant-General, his immediate superior, recognized his qualities and respected him, though with a sullenness and a temper that occasionally led to a rupture with the subordinate, who was of a proud and independent spirit. But the coolness and dignity of Mr. Raman soon won him the regard of the British officer, and the subsequent official life of Mr. Raman at Rangoon ran smooth and unruffled.

His brisk habits and almost irrepressible energy must be felt by all who came into contact with him. Some years after, an Accountant General, who went round on a tour of inspection, was so much struck by Mr. Raman's aggressive individuality that he asked his superior, "How do you manage Raman ?". Dr. King of the Benares Hindu University, being struck by the marvellous energy of Mr. Raman's movements, was forced to remark, "It is indeed a matter of great surprise that flasks and test-tubes survive Mr. Raman's handling in the laboratory."

IN MADRAS AGAIN

The stay of the young officer at Rangoon was not long. About March 1910, hearing of

his father's demise, Mr. Raman took leave for six months and went to Madras. Thus his official life was suspended for a time, but not his scientific activity. The laboratory of the Madras Presidency College was open to him, and his whole time was spent at the altar of Science for nearly the entire period of six months, till September 1910.

MR. RAMAN AT NAGPUR

We next find Mr. Raman at Nagpur as Deputy Accountant-General. Just about this time, the whole city was in the grip of a deadly plague. There were deaths on every side; the people were falling off like the leaves of autumn. The Deputy Accountant-General was very prompt and energetic in his relief measures. There was a large office-compound, where Mr. Raman ordered a number of tents to be pitched for the accommodation of his assistants. He too resided in one of the tents and was ever ready to respond to every call of distress. His almost inexhaustible energy was taxed to the utmost in his efforts to prevent the spread of the epidemic. He personally argued out the

exigency of the situation, and the consequent necessity of special measures with the chief of the Police Department at Nagpur. It was with the greatest difficulty that Mr. Raman could manage to keep his whole staff of assistants free from infection.

When the plague had passed away, Mr. Raman was faced with another kind of trouble. This time his enemy did not come from without. The difficulty came from his own subordinates in the office.

The predecessor of Mr. Raman had created a bad custom in the office. He had deputed one or other of his European assistants with most of his important powers; so that the routine of the office work could go on without his immediate supervision. Thus, as time went on, the European assistant usurped most of the powers of his chief officer, and the latter came to occupy a position not much different from that of "the fifth wheel of the coach". He had become only the titular head of the office while the virtual administration was with his European assistant. It was, when the affairs in the office were in such a

state, that Mr. Raman was posted as Deputy Accountant-General to Nagpur.

Soon after his arrival, Mr. Raman was duly informed of the peculiar practices which obtained in his office. He carried on a silent and secret investigation into the way in which the office work was being carried on. He found that discipline was lax ; and there were very few even among the clerks who really tried to discharge their duties properly. At once, he decided that such a state of affairs should not be allowed to continue. He called for the file of office orders without any delay ; revoked all those which conflicted with the general practice ; warned his immediate assistants against any further encroachment upon the powers of their chief ; threatened with severe penalties any the least infringement of the rules and regulations of the Civil Service, and for all that was outwardly known, sent a tremour into the hearts of his subordinates. The rule of an imbecile officer had ceased. A strong and vigorous administration began with the advent of Mr. Raman who was now barely two-and-twenty,

and his subsequent action in dealing with the recalcitrants in office led to a storm in the tea-pot. Mr. Raman took drastic steps to restore discipline and the AMRITA BAZAAR PATRIKA took up the cause of the victims. The conspiracy of the whole staff against what was thought an young and inexperienced Indian Officer was brought to the notice of the Headquarters in Simla. Luckily, the Accountant-General thought that the measures taken by Mr. Raman were exactly those which any competent officer would have taken, and he expressed his satisfaction with Mr. Raman. At last, when the whole file returned to the official-in-charge at Simla, he could not help remarking that it was indeed a matter of great surprise, how Mr. Raman, so young, could cope with a situation, so serious, in a manner so brilliant! He asked his personal congratulations to be communicated to the young officer, who, he did not doubt, had a glorious future before him.

AT CALCUTTA AGAIN

In November 1911, Mr. Raman was transferred to Calcutta, the scene of his early

labours, as Accountant-General of Posts and Telegraphs. He rejoiced at the prospect of going back to his beloved city. "This city" he said, "is the only proper place for me. I have lived in innumerable cities and countries of the world. I have worked in different laboratories in Europe and America. But I have always felt that Calcutta is the place for me and the Indian Association for the Cultivation of Science is my proper home."

THE PALIT PROFESSORSHIP

It was at this time that University education in Bengal was dominated by a masterful personality—the late Sir Asutosh Mookerji. Sir Asutosh was not only a great educationist but an organizer as well.

In the year 1915, the Calcutta University College of Science was founded through the exertions of Sir Asutosh Mookerjee, and with the help of the princely donations of Sir Taraknath Palit and Dr. Rash Behari Ghose. The opening of this institution marks an epoch in the history of Science in India. Sir Taraknath Palit, "whose name will be handed down to posterity and will be gratefully mentioned by

all true lovers of education from generation to generation, even long after the present-day notabilities—euphemistically so called—shall have passed into inevitable and well-merited oblivion, endowed the Calcutta University with a fund for the creation of a chair in Physics." Thus money was forthcoming. Facilities were quickly being provided. But the men were wanting.

Sir Asutosh had tried many fresh graduates from the University but in vain. It has already been said that his attention was arrested by the work of Mr. Raman in the Indian Association for the Cultivation of Science. His keen eye had not failed to observe his genius. He had been struck by his (Mr. Raman's) scientific ardour and originality. He had closely followed his achievements carried out under the most unfavourable circumstances. He had watched with a personal interest and curiosity, the anxiety of a Government Civil servant for scientific research and original discoveries. He had, therefore, unhesitatingly offered him the Chair of Physics. The offer was first made in the

early months of 1914, when Mr. Raman was not yet past five-and-twenty, and he accepted the post on his own terms. But there was yet another obstacle. The Palit Deed made it compulsory that the Professor should be an England-returned gentleman. Though Mr. Raman had agreed to this provision, he was sorely tried in heart. It was at this time that Sir Guroodas, the friend and admirer of Mr. Raman, came to his rescue.

One day, soon after his appointment Mr. Raman went to see Sir Guroodas Banerjee at his residence. There reigned a luxurious after-tea atmosphere. The host was in his best spirits. His thought ran riot and his peculiar graces of speech and expression had great effect on his listeners. As soon as he saw Mr. Raman, he welcomed him with the utmost cordiality. There was mutual love and confidence between Raman and Guroodas. So there was a deeper speech between them than what words could express. Sir Guroodas had already heard of Mr. Raman's appointment. He was also

aware of the condition of European training which attached to the appointment. So the first thing that he asked of Mr. Raman was, "Then, you are going to England, Mr. Raman?" "I am not going and I do not wish to. But they insist on it." said Mr. Raman. In the twinkling of an eye, the great old man saw that the aggressive personality of the Bengal Tiger had done its work. At heart, Mr. Raman did not like to go to Europe. Sir Asutosh Mookerjee had coerced him into consent. "They tell me" said Mr. Raman that the Palit Trust Deed insists upon an European training for the Chair-holder. "I know not what to do." Thus when Mr. Raman opened his heart to Sir Guroodas, he came to his rescue by opposing the idea and pointing out its unfavourable implications. "You should not go to Europe" exclaimed the grand old man with great emotion. The condition is impliedly a disgrace to Indian talent. It makes European training a condition precedent to the development of original research in India. It perpetuates Indian dependence on European

leadership. It thus defeats the noble object for which Sir Asutosh has so manfully fought the intellectual redemption of the Indian nation. It would therefore almost amount to a suicidal policy. The author of the Trust Deed did not fully foresee these deeper implications. The spirit of it is in your favour. Its letter is immaterial. You may therefore tell Sir Asutosh, point-blank, that you cannot undertake a sea-voyage." Mr. Raman felt relieved by the speech of Sir Guroodas, a clever jurist that he was. Sir Asutosh fell in with his idea. He was not like any other Vice-Chancellor. His position in the Calcutta University was like that of a Dictator. His colleagues understood his disinterested motives. He made himself understood. All knew that whatever he did was for the best interest of the University. No one dared to question his sovereignty. He was magnanimous to the core. He saw that Mr. Raman was indispensable. He accordingly tried to accommodate him as far as he could. The preliminary difficulties were thus overcome. Sir Asutosh's joy knew no bounds. His heart was

fully satisfied. Giving full vent to the inmost feelings of his heart, while laying the foundation-stone of the University College of Science on the 27th of March 1924, he spoke as follows :—

For the chair of Physics created by Sir Taraknath Palit, we have been fortunate enough to secure the services of Mr. Chandrasekhar Venkataraman, who has greatly distinguished himself and acquired a European fame by his brilliant researches in the domain of Physical Science, assiduously carried on under the most adverse circumstances amidst the distraction of pressing official duties. I rejoice to think that many of these valuable researches have been carried on in the laboratory of the Indian Association for the Cultivation of Science, founded by our late illustrious colleague, Dr. Mahendralal Sircar, who devoted a life-time to the foundation of an institution for the cultivation and advancement of science in this country. I shall fail in my duty if I were to restrain myself in my expression of the genuine admiration I feel for the courage and spirit of self-sacrifice with which Mr. Raman has decided to exchange a lucrative official appointment for a University Professorship, which, I regret to say, does not carry even liberal emoluments. This one instance encourages me to entertain the hope that there will be no lack of seekers after truth in the Temple of Knowledge, which it is our ambition to erect.

Thus did Mr. Raman gracefully put on the mantle of Professorship. His work was fully appreciated and highly admired. The Vice-Chancellor seldom blundered in the selection of the College staff. Mr. Raman chose his right profession and Sir Asutosh chose the right professor ; and neither had any cause

to regret the choice. The Vice-Chancellor was ever generous in the tribute of praise he paid to recognized merit, and took every opportunity of expressing his heart-felt admiration for Mr. Raman's genius and character, and holding him up as an ideal to the rising generation of young men in the University.

But even his professorship was not altogether smooth sailing for one of Mr. Raman's strong individuality, especially when it is pitted against another individuality equally strong. The mutual admiration of the Vice-Chancellor and the Professor was not long to continue uninterrupted. A ripple of a misunderstanding arose out of the management of finances during Sir Asutosh's absence on the Calcutta University Commission. Scientific apparatus and instruments had to be purchased locally at heavy price by the Professors without waiting for sanction from duly constituted authorities. Mr. Raman insisted on the right of the Professor to act in the manner he had done, while Sir Asutosh on his return insisted on sanction through the proper chan-

nel in the interest of discipline. The shadow of a misunderstanding had crept in which well nigh tried the Professor to the breaking point. But Sir Asutosh magnanimously made peace, and the rupture which had begun at the first meeting was made up at the second.

DR. RAMAN AND HIS PUPILS

As a teacher, Dr. Raman (who was made an honorary D.Sc. of the Calcutta University in 1921) has endeared himself to his students and inspired them with his own zeal for knowledge. Indeed, under his guidance, the Department of Physics, in the Calcutta University, has become a striking institution of its kind in the world. Like Sir P. C. Ray and Sir J. C. Bose, Dr. Raman too can boast of a host of student scientists who carry on the work of the master with distinction. From his Research School have come Dr. S. K. Banerjee, Dr. Ramanathan, and Dr. B. N. Banerjee, the first fruits of Dr. Raman's teaching. These have since been invited to hold high and responsible posts in the Meteorological Department of the Government of India. Prof.

Phanindranath Ghosh has made a substantial contribution on the theory of vision through optical instruments. Many German scientific journals have referred to his work in Applied Optics, under Prof. Raman's guidance with great praise. Prof. S. K. Mitra has distinguished himself by his remarkable theory of the heliometer, and is Professor of Physics at Khaira. He has organised the wireless department of the Science College. Dr. N. K. Sathi, now of the Benares Hindu University, has published several very useful and important papers on the theory of *White Light*. Mr. N. K. Sur is another very important name. He has published the first experimental verification of the new theory of the Thermal Ionisation. From his laboratory at Allahabad have appeared a number of Spectroscopic papers of great value which have been frequently referred to in the German Handbook of Physics. Mr. R. N. Ghosh, who received excellent instruction in the field of Acoustics under Dr. Raman is now continuing his researches further into the field of musical instruments such as the Pianoforte. Dr.

Bidhu Bhushan Ray, whose brilliant work on Diffraction Halloes, submitted for the degree of Doctorate in Science, was so highly commented upon by such great scholars and experts as Dr. Simpson and Sir G. Walker, and who had received a scholarship for study abroad, was one of the early students of Dr. Raman. Mr. Chinmayanandana was one of the first of those young men who took the guidance of Dr. Raman in Scientific research. His work was very highly appreciated, and he was given a Government appointment. Much was expected from him ; but death cut short his life. The list given above is neither representative nor complete. Dr. Raman had in his laboratory students coming from all the provinces of India and belonging to the different universities. His fame has attracted scholars to Calcutta. The famous saying of Principal Archibald comes back to our memory, "Fine buildings do not constitute a University ; but it is an assembly of scholars which constitutes a University." In the truest sense of the word, Dr. Raman and his students have made up the Physics Section

of the University of Calcutta. "Dr. Raman is still young and full of life and activity, and unlike some of his brother Professors at Calcutta, devotes his whole energy to his subject. Let us hope that he will live long enough to make the Indian Science Association equal in reputation to the Davy-Faraday Laboratory of London."

DR. RAMAN AS A SCIENTIST

We must now come back to Dr. Raman himself. We shall have to say a great deal of his researches in Science, but we must begin with the picturesque side of his research work. Dr. Raman has a passionate longing for the observation and enjoyment of natural phenomena. While on board the steamer bound for Great Britain, he did not lock himself in his cabin and keep pouring over books of science, but he went out into the open air to watch the changing hues of the sky and also the flakes and spumes of the sea. His explanation of the colour of the sky and the *Blue* of the Mediterranean had such an origin. They were not subjects which suggested themselves to him in his study or in his

elaborate Experiment-rooms. They were the direct outcome of his free and undisturbed communion with Nature.

It is again needless to exaggerate the importance of science and the necessity of scientific research in India. It is only a scientist that can speak on the subject with authority. Therefore we refer the reader to Dr. Raman's remarks, during his Convocation Address at Benares, in 1926.

We live to-day not in an age of the Vedas and the Upanishads; we live in a modern age; we live in an age of research; a period of intense striving to create new realms of thought, to penetrate the mystery of nature, by the use of all intellectual and material forces under human command. During the last one hundred years, vast fields of new knowledge have been discussed and cultivated and everything points to an increasingly vigorous advance into regions as yet unknown. We in India, as a people, cannot afford merely to stand aside and be merely passive spectators of this remarkable outburst of human activity. To stand aside would be to confess ourselves an effete and worn-out people, fit only to be laid on the shelf and suffer economic and political extinction.

In these words, Dr. Raman has not only struck a note of warning to help us in our conduct for the future, but has also given a lesson we have to learn from our past experience. It was our past aloofness, that dug the grave of Indian in-

dependence. It was our indifference to what was going on around and in the rest of the world that has been the main cause of our political subjection. Greater contact with the outside world, greater interest in international activities, deeper insight into the general course of the world-progress, are indispensable not only to our fuller life and speedier growth but also to our economic and political redemption. These virtues are equally indispensable to the cultural growth of a nation as well.

"What is Research?" asks Dr. Raman and his answer is, "It is only seeking after knowledge and must therefore be of the most fundamental significance in all schemes of education. You must remember that knowledge at the present day is not a dead knowledge enshrined in books but a living and growing knowledge with which we are all concerned. Can you imagine for a moment that living knowledge can be procured, can be obtained merely by the study of books, by turning your teachers and students into mere book-worms? No! your teachers and students will have to take part in that stream of human activity, which I have referred to. A University is not a university if this is not understood, if this is not daily practised. It is in the attempt to discover new facts and new relations between known facts, which we call research, that a true insight into the new and growing body of knowledge is obtained. You must be one of the seekers, or else you will be left behind."

Dr. Raman has always insisted on Science for its own sake and for its possible utility to-

the race at large. He warned scientists against the temptation to self-advertisement, "I would warn my young friends" said he :

very specially against regarding research as a pathway to self-advertisement and self-glorification. Self-advertisement, for whatever reason it may be pursued, soon becomes an end in itself and its results are most evil when seemingly it is most successful. The man of Science who habitually indulges in it soon comes to believe in his own perfection and infallibility and loses that clearness of vision and rigid self-criticism, essential to an investigator. Self-praise is scientific suicide,

HIS GREAT WORLD TOUR

After Dr. Raman was presented with a Fellowship of the Royal Society of London, he received invitations from various Western Scientific Associations and Research Institutes. Chief among them were those of the British Association for the Advancement of Science at Canada, and the Managing Committee for the Celebration of the Centenary of the Kelvin Institute at London. As a representative of the scientific genius of India, Dr. Raman was the recipient of the most cordial and unique reception not only from the above centres of scientific research but also from the various institutions which he had to visit, on invitation, during his long tour of nearly ten months.

Immediately after leaving India, Dr. Raman proceeded to London to attend the meeting of the Royal Society. He was formally admitted as a Fellow, and he took an active part in the deliberations of the meeting. He spent three weeks in England, most of the time working in the Davy-Faraday Laboratory of the Royal Institute testing one of his new theories in X-ray scattering. Soon after, he attended the Kelvin Centenary held in London. Then without further delay, he left for Canada, to take part in the meeting of the British Association for the Advancement of Science. Originally, he had been asked to read a paper relating to his work. But when he was actually in Toronto, he was agreeably surprised to find that he had been put down to open a discussion on his special subject, and had thus the privilege of addressing the Association for one hour on the subject of Molecular Scattering of Light.

It was while he was leaving the hall that Dr. Raman made the acquaintance, and at once the friendship of one of the greatest physicists in the world. "Prof. Raman", said a gentle-

man approaching him, " I am delighted to meet you and make your acquaintance." That was Prof. Millikan, the Noble Laureate in Physics, and the most active and distinguished of American Physicists in modern times. He at once expressed a desire that Dr. Raman should visit his institution at Pasadena, and lecture to the group of Physicists which he had gathered together at his Norman Bridge Laboratory, where in previous years, some of the most distinguished European physicists such as Einstein and Lorentz had held the position of Research Associates. Dr. Raman too was offered the same position for that session because, Prof. Millikan said, he would greatly value the privilege of having a physicist from Asia to expound his view and put his work before the staff of the Institute. Dr. Raman accepted the invitation.

Simultaneously with the meeting of the British Association, Dr. Raman had to attend the meeting of the International Congress of Mathematicians, at which he had to represent the University of Calcutta. He was asked to preside over the section of Mathematical

physics. There he made the acquaintance of several great mathematicians from all over the world and received a pressing invitation from the Russian Representatives, to visit their country and lecture before their Academy.

When the meetings were over, Dr. Raman was invited to take part in pleasant excursion across Canada by a special train. On the way, he visited several Canadian Universities, and a great many of the attractions of Canadian natural scenery such as lakes, glaciers and mountains in national parks. The three weeks thus spent by Dr. Raman in the company of the most distinguished physicists and mathematicians of the world was an exceedingly pleasant and profitable time. He enjoyed many interesting and instructive discourses, in particular with Prof. Edington of Cambridge, regarding the most recent development in the *Theory of Relativity* and of "Stellar Evolution" with Sir William Bragg on "Crystal Structure" and Atomic Physics; with Sir Richard Paget on his Latest Investigation, "The Nature of Speech", and with a great many others of

equal merit and of less renown. Dr. Raman had many interesting and wonderful experiences during this journey. Suffice it here to say that he had special opportunities of making observations on the colour of the ice in glaciers and of water in mountain-lakes. He had originally planned to make this study in Switzerland, but as good luck would have it, he was able to achieve his object during his Canadian tour. When he visited the Iuisiluwet Glacier on the Rocky Mountains, and climbed up the mass of ice, he was struck at the wonderful greenish blue colour it had exhibited. Dr. Raman hewed down a block of ice, and when he held it in his hand, he saw that it was a perfectly transparent and colourless crystal. He at once put forward tentatively the theory that the colour was due to the selective scattering of the blue end of the solar spectrum where light traverses a mass of ice. Prof. H. T. Barnes of the McGill University of Montreal, who has made a special study of Icebergs and Glaciers in Canada and Greenland, refers in the following words to Dr. Raman's view, in a book recently

published by him on this subject. "It seems more than probable that Prof. Raman is correct and that the colour of ice is due to large group molecules." During his tour in Canada, Dr. Raman, as we have already said, also visited and boated upon a great many of the Canadian fresh water lakes. These sheets of water which are situated in the more rocky and inaccessible parts of the mountains showed wonderfully intense colour ranging from green in some cases to deep-blue in others. The cause of this coloration was due, according to Dr. Raman, to the absorption of light in water combined with the scattering of light in traversing the water by the molecules of the liquid, as well as, in many cases, by the innumerable particles brought down by the glaciers and held in suspension in the lakes.

Returning after those excursions, Dr. Raman had a brief rest at Toronto. Then he went to Philadelphia to attend the Centenary of the Franklin Institute. Here he met Professors Michælson, Zeeman, Fabray, and other physicists of international fame. At the

celebration of the Centenary, he presented the greetings of the Calcutta University and the Indian Association for the Cultivation of Science, which were vociferously applauded. There he also found Prof. Millikan with an official letter appointing Dr. Raman as a Research Associate of his Institute at Pasadena.

Leaving Canada, Dr. Raman went down to the United States and visited by invitation the chief Scientific Institutions at Washington, Chicago, Philadelphia and Iowa. He spent an extremely good time with Prof. Nicholas of Chicago, and visited a field of ten miles outside the city, where the one-mile-long pipe-lines were being laid down. At Iowa, Dr. Raman was received with the greatest cordiality. He delivered a public lecture to a crowded audience. Then he was also specially requested to advise the members of the Physics staff on the research problems they had on hand. Then he went across the United States to Southern California and visited the famous Lowell Observatory at Fagstaff and also the Grand Canyon of Colarado River, in

Arizona. The latter is one of the greatest wonders of the world.

Thence without further delay, Dr. Raman proceeded to Pasadena. He was warmly welcomed by Prof. Millikan and his brilliant group of men. There were Ebsrite, Tolman Noyes, and Bateman. There were besides, numerous other notabilities who had gathered together at the California Institute during the whole period of his stay, and he was overwhelmed by the hospitality with which he was treated by the Institute and the citizens of Pasadena. He lectured regularly on "Thermo-Dynamics and Light Scattering" to the staff and the Graduate students. Many of the distinguished members of the Institute and of the Solar Observatory of Mount Wilson, were among the audience. Dr. Raman spent several weekends touring among the mountain-valleys, beaches and the desert-lands of that wonderful country which has a charm of its own. There he had the privilege of having the great 100-inch reflector of Mt. Wilson of the Mt. Wilson Observatory, practically to himself for two nights in succession. It is decidedly the largest

telescope in the whole world. Dr. Raman appreciated the wonderful engineering skill that is exhibited in the construction and handling of this giant instrument. The almost wonderful light-gathering power of the instrument makes it possible to reach by direct vision, the most outlying parts of manifested creation. Objects whose structure could previously be determined only by prolonged photographic exposures, can now be seen visibly by this 100-inch reflector. Dr. Raman was deeply impressed with the spectacle which the gaseous and planetary nebulae presented in this instrument. He said, "Altogether, what I saw in Mt. Wilson would alone have justified my journey from India to the other side of the earth".

Dr. Raman also delivered several popular lectures upon the ancient educational systems of India and the glories of the Indian civilization. These lectures were heard by crowded listeners, who were so anxious to learn of the contributions of Ancient India to the civilization of the world. Their enthusiasm was evidenced by the innumerable letters of appreciation which were published, and the-

resolutions which were passed. Many a time, Dr. Raman was the guest of honour at the most exclusive clubs in the city and spoke on a variety of subjects.

Dr. Raman was profoundly impressed during this stay at Pasadena with the attention paid to the military training of students. He says,

Rarely a day passed in which I did not see in the compass of the institute, at all hours, groups of students, marching, drilling, learning to shoot, and perform the duties of the soldier. Indeed, it might have seemed that the students were training to become professional soldiers, and not, as in reality they were, electrical engineers. The conviction was borne in upon me that nothing helps a young man, to acquire physical stamina, discipline and a right outlook on life, so much as military training. I regard military training as an essential part of any scheme of education in a University.

After spending three months at Pasadena, Dr. Raman left, but reluctantly, for Northern California, spending the X-mas holidays amidst the beauties of the Sierra Nevada mountain valleys. Whence, he visited the lovely University of Palo-Alto, founded by Prof. Leyland Stanford, where he lectured to the students and staff on his new discoveries. To describe closely the story of this most interesting travel will undoubtedly swell these pages into a big volume. To make a long account

short, Dr. Raman travelled through America, paying visits, and lecturing to the innumerable State Universities of that country which Lord Bryce has truly characterized as the latest of time, but some of which Dr. Raman has described with equal truth as youthful giants. In New York, and Schenectady, he saw, by special invitation, research laboratories of the Western Electric Company, and the General Electric Company. Here he was greatly impressed by the immense amount of attention paid to scientific researches. A great deal of them were purely of academic interest; but were largely financed by industrial organizations and wealthy private individuals on purely business lines.

Dr. Raman left America with regret for England. He had now but two weeks to spare, which he wanted to spend in a continued tour.

First, he sailed for Norway landing at Bergen to meet his friend Prof. Bjerknees, the world-famous meteorologist. The beautiful situation of the city and its inland harbour have left a very pleasant impression upon Dr. Raman's mind.

Then, there were flying visits paid to Oslo, Stockholm, Copenhagen, Berlin and Paris, where he met the leading workers in cognate subjects. His most memorable experience was the day he spent as the guest of Prof. Neils Bohr who to-day stands undoubtedly as the most romantic figure in the world of science. A comparatively young man, his ideas have captured the attention of physicists and chemists all the world over. He practically dominates the scientific thought of to-day. At the Bohr laboratory, Dr. Raman met his former pupil, and a distinguished alumnus of the Calcutta University, Dr. Bidhu Bhushan Ray.

Among other eminent scientists that he met during this short but highly interesting tour were Prof. Stormer of 'Aurora Borealis' fame, Prof. Svedbrg, the most distinguished Colloid Chemist now living, Prof. Arrhenius, Director of the Nobel Institute at Stockholm, Goldchmidt of the Mineralogical Institute, and Nernst of Berlin, Prof. Brillowin of the College of France.

Then Dr. Raman left for India and landed on its shores on the 18th of March, 1925, after

an absence of nearly ten months, with pleasant recollections and indelible impressions of the most brilliant minds of the scientific world and the most varied types of country and civilisation.

A few months after, he left India in response to an invitation from the Russian Academy of Science on the occasion of their Bicentenary Celebration.

SOAP BUBBLES

Prof. Raman has not been content to rest on the laurels he has already won. His subsequent discoveries have been no less remarkable. He made an interesting discovery regarding the construction of soap bubbles. He has described it thus :—

As a soap bubble grows thinner by gradual draining off of the water in it, a stage is reached when at the top of the bubble appears a round black spot; this continually dilates till it becomes sometimes more than half or three-quarters of an inch in breadth before the bubble bursts. This "black spot" represents a film of extreme tenuity, and an immense amount of research has been devoted by physicists for 50 years to the task of determining its exact thickness and physical nature. The thickness of the black spot has been measured by various physicists who have found that the film is only about a five millionth part of an inch in thickness, indicating that it is just a molecule or two thick.

A soap bubble of sufficient thinness is not an ordinary liquid, but a liquid crystal, and should behave optically

in the same way as a section of a crystalline rock or mineral does under the microscope.

Prof. Raman has shown this to be actually the case. A soap bubble is blown to such a thinness that it ceases to exhibit vivid colours and is just full white. This is the stage just prior to the development of the "black spots". The bubble is placed between two large Nicols or polarizing prisms of ice-land spar, and examined under the intense illumination provided by a quartz mercury vapour lamp. When the Nicols are suitably turned with respect to each other, two hyperbolic arcs of darkness appear on the bubble. These arcs are dark when the bubble is freshly blown, but as the stratification develops, they light up, showing the transformation of the soap-film from an ordinary liquid into a liquid crystal. The edge of the black spot at the top of the bubble becomes at the same time intensely luminous.

THE RAMAN EFFECT

But by far the most notable contribution of Dr. Raman to the world of science is what is known after his own name—The Raman effect.

Physicists throughout the world are deeply interested in this discovery of a new radiation-effect. The Raman-effect, is the most discussed question in physics to-day. Numerous papers and reports dealing with it have already appeared in the scientific journals and the foremost centres of research in Europe have taken up the study of the new phenomenon.

The discovery made by Prof. Raman is that when light falls upon molecules of matter and is scattered by them, a remarkable change occurs, which is most readily perceived by observing the scattered light through a prismatic spectroscope.

EFFECT EXPLAINED

For the purpose of these experiments, it is most convenient to use as source of light, a mercury-vapour lamp. This gives a very intense white light which, when examined through a prism, appears resolved into a spectrum containing a few bright lines of different colours, a bright indigo line, a blue line, a green line and two yellow lines. When the light from such a lamp passes through a transparent liquid or solid such as water or ice, the light scattered within the substances when observed through a prism is found to show a number of new lines not present in the light of the mercury arc itself.

This strange phenomenon is exhibited by all transparent bodies, the position and the number of the new lines being different for different substances.

As regards the field of research opened up by this discovery, a writer points out in the columns of a leading newspaper in Calcutta .

Apart from the fundamental interest of the radiation-process revealed by the discovery of the Raman-effect, the study of the new spectra thus produced opens up a wonderful field of research for the investigation of the constitution of molecules and of matter generally, and of its optical properties. So great is this field that Prof. R. W. Wood, a very distinguished Foreign Member of the Royal Society of London, in cabling to the Editor of *Nature* confirming the Raman-effect, characterizes it "as a surprising and brilliant discovery with immense potentialities."

In recent years, says another writer, various experimenters have succeeded in showing that the electrons under certain circumstances behave like waves not unlike those of light. Heretofore, however, they had been considered as very minute particles of negative electricity whose charge and mass had been measured. Exactly parallel to this situation was that of the nature of light. For many years, we had known that light also behaved in a dual fashion : that is to say, under certain conditions, it behaved as if it were a wave motion, and under other circumstances, we found it to possess a corpuscular nature. Our dilemma is now complete regarding the

nature of two fundamentals of nature—the electron and light.

It is very interesting to note that the Raman effect which is a phenomenon that concerns light, also has a parallel in the domain of electronics. In the Raman effect what is believed to happen is that a large part of the energy which disappears from the incident beam is scattered as Tyndall radiation and a small part is emitted as Raman radiation of longer wave-length. Similarly, when electrons of a given velocity are allowed to impinge on gas molecules, a larger proportion of them scatter, maintaining the same initial velocity, and a small fraction go forth possessing a definite velocity which is lower than the original.

THE COMPTON EFFECT

The Raman effect also has a counterpart in the domain of X-rays, which is known as the Compton effect. In the Compton effect, we observe that when X-rays are passed through a gas, they are scattered and a new radiation is emitted in addition, which is of a longer wavelength, similar to the Raman Radiation.

But the distinction lies in the fact that additional high speed electrons are liberated in the Compton effect, which are absent in the case of the Raman effect. Corresponding to the energy used to liberate these electrons in the former case, we have in the latter, according to Raman's view, the atoms in the molecule set in vibration. Thus from the observed Raman radiation, it will be possible, on the basis of quantum theory, to draw conclusions regarding the molecular structure of substances. Herein, a new tool has been discovered by means of which spectroscopists all over the world are now busily engaged in further investigations to explain the behaviour of molecules and to decipher their constitution.

As soon as the discovery was announced from Calcutta, many Physicists in Europe set to work to verify Prof. Raman's result, and their researches have afforded complete confirmation of the discovery and of its explanation given by Prof. Raman. Prof. Pringhheim of the Berlin University with his students, has been investigating the Raman effect, and his report, therefore, carries great weight. In his article in a German Scientific Journal, he introduces several new words, such as "Raman-spectra" and "Raman-lines", as very convenient for use in describing the results in this new field of research. Prof. Pringhheim's report concludes with the significant passage.—"Upon one point, no doubt can exist, that through his discovery, Raman has opened up a great and completely new region in Spectroscopy."

ELECTRICAL FLUID IN METALS

The name of Prof. Raman has been popularly associated with his remarkable discoveries in the field of Light. But his researches comprise all sections of physics and some very promising discoveries about the electrical

conductivity of metals are foreshadowed by a recent interview obtained from the Professor.

It is a very natural assumption to make, Sir C. V. Raman declared, ' that in the electrical conductors, the ultimate particles of electricity, namely, the electrons, are mobile and free to change their positions, while in electrical insulators, they are anchored more or less firmly to the atoms of the solid, and therefore in a position to resist the electric stress. This view, though so apparently plausible, presents some serious difficulties. Why are only some of the electrons in a metal mobile, and how is the evident fluidity of part of the electricity to be reconciled with the solidity of the rest of the electrical structure of the metal ? Physicists have been seeking a way out of this, and other more recondite difficulties, by endowing the electric fluid with strange new properties such as would be possessed by ordinary atoms and molecules only at the absolute zero or nadir of temperature. Here, the question may be asked : Is there any evidence, apart from electrical conductivity, for the presence of electrical particles whose behaviour is different from that of the rest forming the crystalline arrangements of atoms in the metal ? Sir C. V. Raman hopes that a direct answer to this question will be forthcoming on a careful examination of metallic powders and crystals by the X-ray methods. Some very interesting X-ray photographs obtained by Mr. Krishnamurthi with powdered graphite which is also a conductor of electricity, indeed seems to furnish visible evidence of the presence of an electric fluid distinct from the rest of the crystalline structure of the substance. While the solid atoms give sharply defined rings in the X-ray patterns, the mobile electric fluid gives rise to sets of diffuse haloes bounded by these rings. The size of the particles of graphite appears, remarkably enough, to influence the distribution of the electric fluid within them, as shown by these X-ray patterns. It is to be hoped that when these results are extended to the case of other substances the existence of an electric fluid in metals will become a demonstrated fact of observation, and not merely a mathematical hypothesis."

INDIAN SCIENCE CONGRESS

No wonder with these discoveries to his credit, Dr. Raman was invited to preside over the sixteenth session of the Indian Science Congress held at Madras in January 1929. As might be expected, Dr. Raman devoted his presidential address to a purely Scientific topic—the problems of the radiation of light—and to the exposition of the nature and significance of the new phenomenon recently discovered in his own laboratory at Calcutta. This developed from the two distinct theories reached in the nature of light and the impossibility of accepting the wave and the quantum theories of radiation as simultaneously true. The new phenomenon that he discovered may be regarded as the twin brother to the Compton effect. He also explained how he worked on his new theory.

He then dwelt on some of the applications of the new effect and pointed out that its potential value was perhaps greatest in the field of chemistry, helping in the mapping of the intra-red spectra of chemical compounds. The

method opens up an illimitable field of research in organic chemistry.

MAGNETIC PROPERTIES OF GASES

Dr. Raman has also discovered a new and extremely sensitive apparatus by which the feebly magnetic properties of gases and vapours may be accurately measured. The apparatus is so delicate that small quantities of the gas or vapour under study will suffice, and with its help, it is readily demonstrated that the rare gases of the Argon type are actually repelled by a magnet. The measurements made with the apparatus suggest that, in certain cases, there is a noticeable increase in the strength of the magnetic properties of a molecule when it passes from the condition of liquid to that of vapour. A large and very powerful electro-magnet has been specially constructed in the laboratory for researches in molecular magnetism. With its aid and auxiliary optical apparatus, it is possible to demonstrate in a visible manner that the molecules of a liquid when placed in a strong magnetic field tend to turn round and arrange themselves parallel to one another. The

effect is very strong in some liquids, such as benzene and carbon-di-sulphide, but is relatively very weak in others such as water, ether or alcohol. In papers appearing in subsequent publications of the Royal Society and of the French Academy, Dr. Raman has shown that the magnetic character of a molecule determined in such observations can be definitely connected with its chemical structure.

LECTURES IN MADRAS

In the autumn of 1928, Dr. Raman visited Madras, where, under the auspices of the Indian Cultural Association, he discoursed on X-rays and his recent discoveries. He said that

X-Rays formed a powerful weapon of research in the hands of the physicist for one reason. The ordinary microscope was no doubt of great practical use to science. By its aid, it had been possible to get at the bottom of a great wealth of phenomena on a small scale. But limits were set to the microscope by the very nature of light whose wave-length was about 15,000th of an inch. If it was possible to use a microscope, in conjunction with X-Rays—whose wave-length was 10,000 times smaller than that of ordinary light—they would have a powerful aid to observation and research.

The Professor then demonstrated by a series of lantern slides how the peculiar molecular combinations of different crystals and liquids could be actually determined by sending the

X-Rays through the object and photographing the refracted rays. Finally, the Professor said that there were great possibilities in the use of X-Rays which was only one of several such divergent optical phenomena of light like the Gamma ray, the cosmic radiation and the ultra-violet ray.

ANDHRA UNIVERSITY CONVOCATION ADDRESS

Dr. Raman was honoured by the Andhra University by an invitation to deliver the Convocation Address. His address was marked by some practical counsel to the organizers and the people of Andhradesa which deserves to be quoted:—

I think it is essential that all colleges which are permitted to undertake degree work should agree to come under University control to a greater extent than at present. In their case, University affiliation should be replaced by University management exercised through the intermediary of a semi-independent Governing Body in which the University Executive is represented, and whose proceedings come up to the Syndicate for review. While such a constitution will leave a reasonable amount of independence to the colleges, it would serve to ensure that their affairs are regulated in a manner more in accordance with University ideals than is the case at present.

The creation of a centre of University teaching as outlined above will certainly be expensive, but I can not see that it can possibly be put off or avoided. A capital expenditure of 30 lakhs and an annual recurring expenditure of 6 lakhs would be a reasonable estimate of the

cost, considering the range of subjects to be covered and the extent of the population whose needs have to be met by the University. With a little judicious pressure from Your Excellency on the Finance Department of the Local Government and upon the wealthy aristocracy of Andhra, the money will, I have no doubt, be forthcoming.

Dr. Raman also urged a close linking up of the colleges and the University and passed on to observe that

It is a matter of most serious concern to every one connected with the Andhra University that no facilities of any kind exist at present in its jurisdiction for higher scientific, technological and literary studies. It is a most pressing duty of the University to organise such studies, and it may rightly be claimed that Your Excellency's Government is under an obligation to provide funds on the most generous scale for this much-needed expansion.

From University organization to University aims and ideals is but a short step and Dr. Raman discoursed eloquently on the aims of University teaching.

The aim of University teaching should be to stimulate and guide the student on the right path, to help him to acquire habits of study and work, and to encourage him to exercise an independent judgment on problems presented to him. Such training is only possible by bringing the student into personal contact with teachers who themselves possess great independence of outlook and live a life of strenuous intellectual activity. To deprive our alumni of opportunities of contact with such teachers and to place them under men of inferior merit is to poison the wells of learning. A University or College which converts its alumni into mere passive absorbers of knowledge is doing incalculable harm to the rising generation.

KNIGHTED

Dr. Raman's distinguished services to the cause of Science, alike by his new discoveries and by the inspiration of his teaching could hardly escape the notice of the high officials of the Government of India. And when on the 3rd June 1929, (the King's birthday), his name appeared among the new Knights, it was universally felt as a fitting and due recognition of undoubted talents and meritorious services. Sir C. V. Raman was soon after entertained by the South India Club of Calcutta in honour of his Knighthood. Replying to the congratulatory address, he acknowledged the honour with a modesty truly becoming the real scientist :

"In this address you have chosen to refer to my contributions to science. I wish to repeat what I said a few months ago as the President of the Indian Science Congress. I say I am just beginning my career, as a man of Science. That is the point of view which I hold, and I feel that the man of Science who looks forward to honours or rewards for his work must consider that his days are finished. That is the spirit in which a man of Science should view his labours."

It is in that spirit that Sir C. V. Raman has lived and laboured. He holds that a man of

:Science should have no ulterior motive and that science is its own reward :—

The man of Science who seeks for any reward or recognition, who seeks for anything except just the pleasure of doing his work, is one who seeks a Will-O'-the-Wisp. Science yields her richest fruits, her noblest rewards, and her most coveted prizes to the man who seeks Science and nothing else. Honours, praises, rewards, these are mere incidents in the life of a true man of Science, and he passes over these without notice. If an occasion arises for his friends, as for example, this assembly, to take notice of it, there is just this human satisfaction that others are pleased at the rewards and recognition of the recipient. As for myself I look forward to my work.

CONCLUSION

Yes ; it is this single-minded devotion to work that has been the marked feature of his life. That was the real cause of his brilliant career at college ; that again has sustained him throughout his subsequent career. In private life, Dr. Raman is distinguished by his gentle disposition and his amiable manners. A brilliant conversationalist, he holds forth with equal interest on a variety of topics, though his forte is, of course, science. And it is the poetic aspect of nature that appeals to him so powerfully. To him as to a poet the rainbow in the sky and the flakes of the sea are charged with profound meaning.

Thus to the critical mind of the trained Scientist he adds the graces of the imaginative mind of the poet. The result is a happy combination of the critical and creative faculties which has proved so fruitful in recent years. Dr. Raman is yet in the prime of life and in the full vigour of his mind. He is comparatively young (being barely 41) and already he has achieved renown as a great scientist. He has yet many more years of active intellectual life before him and we have no doubt he will still further enrich the field of researches and prove to the world that modern India, no less than the ancient, has her own contributions to add to the advancement of human knowledge.

PROF. RAMACHANDRA

EARLY YEARS

PROF. RAMACHANDRA, the subject of this sketch was born in 1821 at Panipet, the famous battle-place, about fifty miles from Delhi. His father was a Hindu Kaeth and a native of Delhi and was employed at Panipet under the Collector of Revenue. After some education in Private schools, Ramachandra entered the English Government School at Delhi where he remained six years. That school does not appear to have paid any special attention to Mathematics, but shortly before leaving it, Ramachandra developed a taste for that subject and studied at home with such books as he could procure. After leaving school, he was employed as a writer for two or three years. In 1841, the Educational Department of the Bengal Presidency was re-organised and the school at Delhi was raised to a College, and Ramachandra

obtained by competition a senior scholarship of Rs. 30 a month. His academic course was brilliant from the first, and he thus maintained himself by winning scholarships and prizes. Starting from a respectable family sunk in poverty, owing to the death of his father, his own studies so rapidly progressed that he became Professor of Mathematics in the College at a very early age.

A TEACHER OF YOUTH

It was in 1844 he was appointed a teacher of European Science in the Oriental Department of the College through the medium of the vernacular. A Vernacular Translation Society was instituted, and under its auspices, Ramachandra translated or compiled works in Urdu on Algebra, Trigonometry, etc. About these translations, Ramachandra writes as follows :—"These translations were introduced into the Oriental Department as class-books so that in two or three years, many students in the Arabic and Persian Departments were, to a certain extent, acquainted with English Science, and the doctrines of the ancient philosophy taught through the medium

of Arabic were cast into the shade before the more reasonable and experimental theories of modern Science." But the significance of the new learning was far-reaching and by no means confined to the technics of the Science. The social and spiritual import of Western Science was tremendous in its consequences. The old dogma, for instance,

"that the earth is the fixed centre of the Universe, was generally laughed at by the higher students of the Oriental, as well as by those of the English Department of the Delhi College. But the learned men, who lived in the city, did not like this innovation on their much-loved theories of the ancient Greek Philosophy, which had been cultivated among them for many centuries past."

Ramachandra goes on to write a further account of the first open conflicts of the New Learning with the Old.

"We commenced," he says, "a monthly magazine at the cheap rate of four pence a month in which notices of English Science were given. Not only were the dogmas of ancient philosophy exposed, but many of the Hindu superstitions were openly attacked. The result of this was, that many of our countrymen condemned us as infidels and irreligious."

In 1850, Ramachandra published in Calcutta his mathematical work on *Problems of Maxima and Minima* which won him immediate recognition in the Universities of Europe. It also brought him to the notice of

the Court of Directors whose help and encouragement was, as we shall show in the following pages, of material advantage to him.

HIS CONVERSION

But before discussing his contribution to mathematical studies, it is necessary to refer to one or two salient features of his life. The first in importance was, of course, his conversion to the Christian faith. We are told that, before his conversion, he was, like many of his educated countrymen, simply a Deist, looking down with contempt on all religions—Hindu, Mahomedan or Christian—which based their teachings on any written book. Idle curiosity, however, took him to the Church one day; he was struck by the piety and devotion of some European friends for whom he had great respect. And then he took to the study of the Bible in earnest, followed by a comparative study of the sacred books of other religions. As the result of these investigations, he became, in the words of his biographer “fully convinced of the truth of the Christian religion.” In fact, the

introduction of the study of English, as Mr. Andrews has pointed out in his *LIFE OF ZAKA-ULLAH*, did actually lead at first to a wide-spread unsettlement in the minds of the young, with regard to the orthodox religions. It was long before any student openly embraced the Christian Faith ; but it was known at a very early date that many of the ablest among them were inclining that way, "and this led to a consternation in homes where conservative piety had hitherto held undivided sway." And as Ramachandra was by far the most advanced in English studies, it was inevitable that his name should be held up for a warning, as to what results might happen if the English language were allowed to be taught to the young. But openly to embrace an alien faith was by no means easy. There were difficulties which had to be overcome. He knew he should have to leave his mother, wife, children and brothers, and meet with great opposition from his castemen. But he braved it all in the fervour of his new faith, and entered the fold of Christ's Church by publicly receiving baptism on the 11th March 1852.

Like all new converts, Ramachandra was a zealous evangelist. "He professed openly that he believed the Christian religion to be true and Hinduism to be false." He continued to teach in the old Delhi College, but he devoted his spare time to religious studies and to conversations on spiritual subjects. The influence he was thus able to exercise on the higher classes could hardly have been negligible.

MUTINY DAYS

But the times were somewhat out of joint. The Great Mutiny broke out in 1858, and Native Christians were at a discount. Hindu and Muslim vengeance alike turned on the converts to the "European" religion and many innocent Indian Christians fell a victim to the fury of the mutineers. It was no doubt true that most Christians, identified themselves with Europeans, and discrimination was out of the question in a time of chaos and confusion. Prof. Ramachandra was himself in some danger, but his Hindu brothers concealed him in their house, "and when he could no longer stay there, he left the city in disguise and eventually after many hair-breadth es-

capes, reached the English force which was then encamped before Delhi".

Mr. Andrews gives a charming account of the affection and devotion of the teacher and his pupils, and his account of Ramachandra's plight at the time of the Mutiny particularly his relations with Zaka Ullah and other disciples is of great interest. He says :

The rumour had somehow got abroad that Ramachandra's own favourite pupil, Zaka Ullah, was about to follow his tutor's lead and openly profess himself a Christian ; but this was never remotely likely to have taken place. It revealed a complete misunderstanding of the situation. Their friendship was of the intellectual type, common among scholars who are solely devoted to learning and engaged in the same search after scientific truth ; for, to both Ramachandra and his young companion, the first approach to Western science and mathematics was full of an intense interest approaching to awe and wonder. It did not mean in this instance spiritual discipleship, although questions of religion must have been discussed between them. At the same time, it is clear that this early and intimate companionship with Professor Ramachandra at the old Delhi College broadened his views of religion and gave to him, from his youth onwards, that width of vision and spirit of tolerance which made his character so beautiful in its powers of sympathy in later years.

Professor Ramachandra was a man of fearless sincerity and very strong convictions. The fact that he had been obliged to break with all his Hindu relations and to undergo much persecution when he became a Christian had made him somewhat stern and abrupt in manner, and often harshly controversial towards others ; but he had a deeply affectionate heart and was upright in his actions.

But the disciple's love of the master was no less marked. The story of Ramachandra's escape from the Mutineers deserves to be told in Mr. Andrews' own words. When the city fell for a time into the hands of the Mutineers, Prof. Ramachandra's life, as a Christian convert, was in the greatest possible danger.

Dr. Chiman Lal, a fellow Christian, a man of sincere piety and given to good works, had been at once killed by the soldiers. A search was then made for Professor Ramachandra. Rai Piyare Lal Sahib, of Delhi, one of the very few survivors, has told me how on the morning that Delhi was occupied by the mutineers from Meerut, at about ten o'clock, he met Zaka Ullah hurrying towards the Delhi College, at the imminent risk of his own life, in order to endeavour by some means to save Professor Ramchandra. He reached the College, but found that the Professor had already been warned beforehand by another of his pupils. Zaka Ullah himself was able to render further aid at this critical moment. Professor Ramachandra remaining for some days in hiding, in the heart of the city, managed at last, by the help of his own students, to escape in disguise to the open country and thus got safely away. He had endured in the interval the most terrible anxiety and suffering.

After the Mutiny had subsided, he was appointed in 1858 Teacher of Mathematics in the Government Engineering College at Rurki, and about the end of the same year, Headmaster of the newly established Government school at Delhi. He was also able to return

some of the kindness of his young friend and pupil, who had helped to save his life by his timely warning. He obtained military passports both for him and for his family, which enabled them to come back into the city. He also did him many other acts of service.

IN PATELIA

Five years hence, a new sphere of usefulness opened out to him. He was appointed tutor to H. H. the late Maharaja of Patiala, a duty which he performed with such credit and distinction that he was called again and again to do the offices of a Prince's teacher in the same State. He was in Patiala for five years from 1863, after which he returned to Delhi to publish his second book of mathematics. A year and a half hence, he was recalled to Patiala where the late Maharaja, on his installation to the *gadi* gave him a *khillat* and a *jagir* in recognition of his valuable services and also appointed him Director of the newly established Department of Public Instruction of his State. As Director, Prof. Ramachandra was able to do a good deal of spade work in the cause of education. He

laid the foundations of a sound and efficient system of education. Though he was *a persona grata* with the Maharaja, the position of a Christian scholar in high office in a Hindu State was beset in those days with peculiar difficulties. But Ramachandra's innate sense of propriety, his loyalty and high character coupled with his zeal in the cause of education tided over the anomalies of his position and he was able to show a good record work. In 1815, he left Patiala having served the State and the Maharaja faithfully for well over a decade.

But his connection with Patiala was not to be snapped easily. For, on the death of the Maharaja, he was called back to Patiala as tutor to the next in throne. And he continued to serve the State faithfully and well, until, in 1879, an attack of paralysis obliged him finally to retire from service. He returned from Patiala very weak in health, and he lay in bed for full five weeks. His last days were marked by much physical suffering, but he bore it with meekness and fortitude. "At his request" says a chronicler, "portions of the

Scripture were often read out to him, and prayer offered by his bed-side. Twice, the Holy Communion was administered to him from which he appeared to receive great comfort." He thus lingered on for a week and "fell asleep in Jesus," on the 11th August 1880.

LAST DAYS

Such in brief outline is the life story of Prof. Ramachandra, who, for a period of some thirty years, gave of his best to his contemporaries. A pious Christian he served the cause of truth according to his light "by pen and purse and tongue". Writing and preaching, he engaged himself in ceaseless controversies for the propagation of the Faith which gave him anchor. His charity was abundant. For, besides many nameless, unremembered acts of kindnesses and love, he was sending the Bishop of Lahore annually Rs. 1,000 for benevolent purposes. Nor was his charity confined to members of his own community. He was known all over the neighbourhood for his piety and benevolence as he led a blameless life of thought and good works. But the

fame of his mathematical researches soon outstripped his reputation for missionary and philanthropic activities. Indeed, in the blaze of his achievements in mathematical scholarship, his other activities have almost faded from the memory of his countrymen. Prof. Ramachandra remains to us a great mathematician and an original and forceful thinker.

A GREAT MATHEMATICIAN

It is therefore in the fitness of things that we should study Prof. Ramachandra in his character as mathematician. And we make no apology for drawing largely from an article from the pen of Prof. P. V. Seshu Aiyar who describes Ramachandra's mathematical achievements at some length in the pages of THE INDIAN REVIEW.*

We have said that Ramachandra's work on the *Problems of Maxima and Minima* was published in 1850. "When I composed my work on the *Problems of Maxima and Minima*," said Ramachandra, in a letter, "I

* May 1927.

built many castles in the air, but the Calcutta reviewers destroyed these empty phantasms of my 'brain.' Help and recognition, however, came to him from some other quarter. Dr. Sprengar, who was formerly Principal of the Delhi College, introduced him to the Hon'ble J. E. Drinkwater-Bethune of the Supreme Council who very kindly received from him 36 copies of his work and paid him Rs. 200 as donation. Also the Hon'ble D. Bethune sent to England a number of copies with directions to present copies to various persons and among others to Augustus De Morgan, one of the most famous English Mathematicians of the 19th century. On examining the work, De Morgan saw in it, "not merely merit worthy of encouragement, but merit of a peculiar kind, the encouragement of which was likely to *promote native effort towards the restoration of the native mind in India.*" Having taken further time to think, De Morgan determined to call the attention of the Court of Directors to Ramachandra's work in the hope that it would lead to acknowledgement of his deserts. After considerable

correspondence between the authorities at Home and in India Dr. Morgan himself was invited to suggest the means of bringing Ramachandra to the notice of scientific men in Europe. In his reply (March 18th, 1858), assuming distinctly the question to be, not merely how Ramachandra could be rewarded, but how his work might be made most effective in the development of Hindu talent, he recommended the circulation of the work in Europe, with a distinct account of the grounds on which the step was taken. He also entered at some length into his own view of those grounds and offered to draw up the statement which should accompany the publication. After some correspondence on details, the Court, expressing entire satisfaction with his views, and characterising them as "deserving of the most attentive consideration by all who are charged with the superintendence of education in India in its higher grades," accepted his offer to superintend the reprint of the work in England for circulation in Europe and in India. Thus came about the London Edition of Rama-

chandra's work on *Problems of Maxima and Minima*. Also the Honourable Members of the Court of Directors were pleased to sanction a *khillut* (dress of honour) of five pieces to be presented to him and also a reward of Rs. 2,000. This is what Ramachandra writes about the honour conferred on him: "I am much thankful to the English Government that they are so bent upon encouraging science and knowledge among the natives of this country, as to take notice of a poor native of Delhi like myself."

DE MORGAN'S PREFACE TO HIS BOOK

Now coming to the intrinsic worth of the work on *Maxima and Minima*, the following extracts taken from De Morgan's preface to the London Edition will speak for themselves:

"The history of England, as well as of other countries having impressed me with a strong conviction that pure speculation is a powerful instrument in the progress of a nation and my own birth (De Morgan was born in Madura) and descent having always given me a lively interest in all that relates to India. I took up the work of Ramachandra with a mingled feeling of satisfaction and curiosity; a few minutes of perusal added much to both. I found in this dawn of the revival of Hindu speculation two points of character belonging peculiarly to the Greek mind, as distinguished from the Hindu; one of which may have been fostered by the author's European teachers, but certainly not the other."

"The first point is leaning towards Geometry. ** The greatness of Hindu invention is in Algebra; the greatness of Greek invention is in Geometry. But Ramachandra has a much stronger leaning towards Geometry than could have been expected by a person acquainted with the *Vija Ganita* of Bhaskara)." **

"The second point is yet more remarkable. Greek Geometry, as all who have read Euclid may guess, gained its strength by *striving against self-imposed difficulties*." ** "Definite limitation of means was imposed as a condition of thought, and it was sternly required that every feat of progress should be achieved by those means and no more." ** "The remains of the Hindu Algebra and Geometry show to us no vestige of any attempt to gain force of thought by struggling against limitation of means." ** But we have here a native of India who turns aside at no suggestion but that of his own mind, and applies himself to a problem which has hitherto been assigned to the Differential Calculus under the condition that none but purely Algebraic process shall be used. He did not learn this course of proceeding from his European guides, whose aim it has long been to push their readers into the Differential Calculus with injurious speed and who often allow their pupils to read Euclid with his eyes shut to his limitations. Ramachandra proposed to himself a problem which a beginner in the Differential Calculus masters with a few strokes of the pen in a month's study, but which might have been thought hardly within the possibilities of pure Algebra. His victory over the theory of the difficulty is complete. Many mathematicians of sufficient power to have done as much would have told him, when he first began, that the end proposed was perhaps unattainable by any amount of thought; next, that when attained, it would be of no use. But he found in the demands of his own spirit and impulse towards speculation of a character more fitted to the state of his own community than the imported science of his teachers. He applied to the branch of mathematics which is indigenous in India, the mode of thought under which science made its greatest advances in Greece." * . . . *

"Ramachandra's problem—and I think it ought to go by that name, for I cannot find that it was ever current as an exercise of ingenuity in Europe—is to find the value of a variable which will make an algebraic function a maximum or a minimum under the following conditions. Not only is the Differential Calculus to be excluded, but even that germ of it which, as given by Fermat in his treatment of this very problem, made some think that he was entitled to claim the invention. The values $f(x)$ and $f(x+2)$ are not to be compared; and no process is to be allowed which immediately points out the relation of $f(x)$ to the derived function $f'(x)$. A mathematician, to whom I stated the conditioned problem, made it, very naturally, his first remark, that he could not see how on earth I was to find out when it would be biggest, if I would not let it grow. The mathematician will at last see that the question resolves itself into the following:—Required a constant, r , such that $f(x)-r$ shall have a pair of equal roots, without assuming the development of $f(x+2)$, or any of its consequences."

The above extracts clearly show vigorous and original thinker Ramachandra was, and how well he was appreciated by the illustrious De Morgan.

RAMACHANDRA'S SECQND BOOK

Encouraged by such appreciation, Ramachandra published in 1861 his second mathematical work on *A New Method of the Differential Calculus*.

There were in those days four different methods in use according to which mathematicians treated of the Differential Calculus, *viz.*, the method of fluxions ; of infinitesimals ; of

limits and the calculus of functions. There were difficulties experienced in, and objections raised against, each of these methods. These objections were stated by the advocates of each of those methods against the others and even sometimes confessed by them in their methods. Of course, each of the methods had its own advantages. Ramachandra fully realised these difficulties, objections and advantages, and set to work to find out a new method of the Differential Calculus which may avoid all that is objectionable in the four methods and which may at the same time combine all their advantages. Though this new method of his is not as satisfactory as he claims it to be, yet this venture on his part to critically examine all the existing methods and devise a new method of his own, shows his grasp of the fundamentals of mathematics and his logical frame of mind, and thirst for rigour in Mathematics, a quality which is not largely found even amongst the Indian mathematicians of to-day.

SRINIVASA RAMANUJAN

INTRODUCTION

VIEWING the works of Srinivasa Ramanujan—the famous Mathematical genius—the LONDON TIMES truly observed that “there is something peculiarly sad in the spectacle of genius dying young, dying with the first sweets of recognition and success tasted, but before the full realisation of the powers that lie latent within”. Such indeed was Ramanujan, who, in his all too brief life, typified “young Lycidas”, who “hath not left his peer.” We are familiar with the names of youthful geniuses cut off in the prime of life before the full tide of accomplishment. Chatterton and Keats and Shelley leap up before our minds as stars of unfulfilled renown in the world of letters. And in Science, it was left for Ramanujan before the age of 27 to develop theories of which Prof. Hardy could write?

It is sufficiently marvellous that he should have even dreamt of problems such as these, problems which it has taken the finest mathematicians of Europe a hundred years to solve, and of which the solution is incomplete to the present day.

EARLY STRUGGLES

Ramanujan was born in December 1887 at Erode in Southern India, and was educated at the Town High School, Kumbakonam. He came of a Brahmin family in poor circumstances, his father and grandfather having served as petty accountants to cloth merchants. His mother was the daughter of a bailiff in a local court of justice. Hence he practically owed nothing to heredity so far as his aptitude for mathematics was concerned. At school, he was observed to be remarkably quiet and meditative while the subtle mathematical problems with which he was wrestling had hardly any meaning to those around him. His parents as well as his school-fellows were utterly innocent of them—a circumstance to which his biographers draw pointed attention. Here is a man, they say, “who rises out of obscurity with extraordinary gifts and struggles to evolve himself and shines out like a self-luminous body.”

AN UNCONSCIOUS GENIUS

It is said that genius is unconscious and that Ramanujan was absolutely unconscious of his genius. This unconsciousness was perhaps the distinguishing feature of his life, coupled with unassuming simplicity of manners. His natural reserve and his mental pre-occupations deterred him from expressing himself on matters concerning his private life: and but for the labours of his patrons, we could have known nothing of the circumstances of his life or his great achievements. In what may be called the Memorial edition* of Ramanujan's works published by the Cambridge University Press in 1928, there appeared for the first time some intimate biographical and appreciative notices by three mathematicians of repute—Dewan Bahadur Ramachandra Row, Mr. P. V. Seshu Ayyar and Mr. G. H. Hardy, F.R.S. It is to these that we owe not only the discovery of Ramanujan himself but also the details of his

* Published by the munificence of the University of Madras, the Royal Society of London and Trinity College, Cambridge, each of which bodies has contributed a share towards the expenses of printing.

extraordinary life: and we make no apology for drawing copiously from their biographical notices.

AN INFANT PRODIGY

When quite a boy at school, we are told, he displayed great curiosity concerning Mathematics, but his amazing powers were not discovered until a far more advanced student lent him Loney's Trigonometry. At twelve, to the astonishment of his teachers, he was able to do every problem in the book unaided. Three years later, he borrowed Carr's *Synopsis of Pure Mathematics*, and Ramanujan "went ranging with delight through the new world thus opened to him." He worked problems in sleep, and he himself believed that his patron goddess, Namagiri, inspired him in his dreams. At the age of seventeen, he won a scholarship at the Government College, Kumbakonam, but he lost it "owing to weakness in English." In fact, he did not care for any subject other than Mathematics, and this, coupled with the need for eking out a livelihood, cut short his College career. At nineteen, he attempted in vain to enter the Univer-

sity and thereupon continued his mathematical researches in private for three years.

THE DISCOVERY OF RAMANUJAN

Those were hard days for him, troubled as he was by "chill penury": and he sought a temporary job in a far-away mofussil station. But it never repressed his noble rage. It was at this time that he luckily came in contact with men who were destined to play a striking part in the subsequent career of this mathematical genius. We must now quote from Mr. Ramachandra Rao's dramatic account of the first interview with Ramanujan :

Several years ago, a nephew of mine, perfectly innocent of mathematical knowledge, said to me: "Uncle, I have a visitor who talks of mathematics; I do not understand him; can you see if there is anything in his talk?" And in the plenitude of my mathematical wisdom, I condescended to permit Ramanujan to walk into my presence. A short, uncouth figure, stout, unshaved, not overclean, with one conspicuous feature—shining eyes—walked in with a frayed note-book under his arm. He was miserably poor. He had run away from Kumbakonam to get leisure in Madras to pursue his studies. He never craved for any distinction. He wanted leisure, in other words, that simple food should be provided for him without exertion on his part and that he should be allowed to dream on.

He opened this book and began to explain some of his discoveries. I saw quite at once that there was something out of the way; but my knowledge did not permit me to judge whether he talked sense or nonsense. Suspending judgment, I asked him to come over again.

and he did. And then he had gauged my ignorance and showed me some of his simpler results. These transcended existing books, and I had no doubt that he was a remarkable man. Then, step by step, he led me to elliptic integrals and hyper-geometric series, and at last his theory of divergent series not yet announced to the world, converted me. I asked him what he wanted. He said he wanted a pittance to live on so that he might pursue his studies.

Thereupon, Mr. Ramachandra Rao, who was then in Nellore, sent Ramanujan to Madras and induced Sir Francis Spring, the Chairman of the Port Trust, to take an interest in him. He rightly held that it would be cruel to let such a genius waste itself in a suburban office. About this time, Dr. G. T. Walker, F.R.S., Director-General of Observatories, Simla, and formerly Fellow of Trinity College, Cambridge, happened to visit Madras and Sir F. Spring took the opportunity to bring some of Ramanujan's works to Dr. Walker's notice. As a result, Dr. Walker addressed, on the 26th February, 1913, the following letter to the Registrar of the University of Madras :—

I have the honour to draw your attention to the case of S. Ramanujan, a clerk in the Accounts Department of the Madras Port Trust. I have not seen him, but was yesterday shown some of his works in the presence of Sir Francis Spring. He is, I am told, 22 years of age, and the character of the work that I saw impressed me

as comparable in originality with that of a mathematical Fellow in Cambridge College. It was perfectly clear to me that the University would be justified in enabling S. Ramanujan for a few years at least to spend the whole of his time on Mathematics, without any anxiety as to livelihood.

This brought him a scholarship of Rs. 75 per month from the University—an award which left him free to pursue his natural inclinations without the bother of labouring for bread. It was then on the suggestion of Mr. Seshu Aiyar and others that Ramanujan began to correspond with Mr. G. H. Hardy, then Fellow of the Trinity College, Cambridge. The first letter which is dated 16th January 1913 contained the following passages :

I had no university education, but I have undergone the ordinary school course. After leaving school, I have been employing the spare time at my disposal to work at Mathematics..... I have made a special investigation of divergent series..... Very recently, I came across a tract published by you, styled "Orders of Infinity" in page 36 of which, I find a statement that no definite expression has yet been found for the number of prime numbers less than any given number. I have found an expression which very nearly approximates to the real number, the error being negligible. I would request you to go through the enclosed papers. Being poor, if you are convinced that there is anything of value, I would like to have my theorems published.....

Ramanujan was so weak in English that Hardy doubts if he could have penned the letter himself. Doubtless, he was aided in his com-

positions by his two distinguished friends in Madras. But the papers that he had sent to Mr. Hardy, which were his own, contained the enunciations of a hundred or more mathematical theorems, all of sufficient interest to merit the esteem of a Cambridge mathematician. Mr. Hardy was struck by the extraordinary nature of the solutions that Ramanujan had adumbrated, and his reply was couched in terms of sympathy and encouragement. Ramanujan followed it up with a second letter on the 27th February 1913:

I have found a friend in you who views my labours sympathetically. This is already some encouragement to me to proceed. To preserve my brains, I want food, and this is now my first consideration. Any sympathetic letter from you will be helpful to me here to get a scholarship.

In the meanwhile, Mr. Hardy was already negotiating with the authorities in London and with the students' Advisory Committee in Madras to provide for Ramanujan the benefits of a Cambridge education. But Ramanujan would not go owing to caste prejudices. This was a great disappointment to Mr. Hardy as he felt that Ramanujan only needed a



PROF. RAMANUJAN, F.R.S.

touch of modern culture and up-to-dateness to his mathematical equipment to enable him to contribute his due share to the advancement of mathematical knowledge.

In the meanwhile, relieved of the drudgery of the clerical post and of the need for labouring for daily bread, Ramanujan employed his ample leisure in furthering his mathematical researches, and from 1st May 1913, he was able to devote himself exclusively to mathematics. And in accordance with the conditions of the scholarship, he submitted to the Board of Studies three quarterly reports on his researches on the 5th August 1913, 7th November 1913 and 9th March 1914.

CAMBRIDGE DAYS.

Early in 1914, Mr. E. H. Neville, M.A., Fellow of the Trinity College, Cambridge, came to India to deliver a course of lectures in Madras.

Mr. Hardy had instructed Mr. Neville to see Ramanujan and persuade him to go to Cambridge. Ramanujan himself by this time had come to realise the need for Cambridge education to complete his studies, and he consented. Mr. Neville thereupon sent a memorandum to

the authorities of the University of Madras on the 28th January 1914. It ran as follows :—

The discovery of the genius of S. Ramanujan of Madras promises to be the most interesting of events of our time in the mathematical world. The importance of securing to Ramanujan a training in the requirements of modern methods and a contact with men who know what ranges of ideas have been explored and what have not, cannot be over-estimated.

I see no reason to doubt that Ramanujan himself will fully respond to the stimulus which contact with Western mathematicians of the highest class will afford him. In that case, his name will become one of the greatest in the history of mathematics, and the University and the City of Madras will be proud to have assisted in his passage from obscurity to fame.

With a further scholarship from the University of £250 a year tenable for two years in England, Ramanujan sailed for England on the 17th March 1914 and was admitted to the University College, Cambridge, which supplemented his scholarship by an award of £ 60. Here under the guidance of Mr. Hardy and Mr. Littlewood, he developed rapidly. On the 11th November, 1915, Mr. Hardy wrote to the Registrar of the Madras University :—

Ramanujan has been much handicapped by the War. Mr. Littlewood, who would naturally have shared his teaching with me, has been away, and one teacher is not enough for so fertile a pupil..... He is beyond question the best Indian mathematician of modern times ... He will be always rather eccentric in his choice of subjects and methods of dealing with them..... But of his extra-

ordinary gifts there can be no question. In some ways, he is the most remarkable mathematician I have ever known.

But the climate of England to which he was a stranger and what was thought his eccentric diet began to tell on his health. And he contracted an incurable disease (tuberculosis) for which he was placed in a nursing home. In those days of submarine warfare, it was not safe to risk a sea voyage, and Ramanujan continued to try different sanatoria in England until the autumn of 1918, when he showed decided symptoms of improvement.

A FELLOW OF THE ROYAL SOCIETY

Meanwhile, the world of Science was apprised of the great mathematical researches of Ramanujan, and on the 28th February 1918, in his 31st year, he was elected a Fellow of the Royal Society—the first Indian to obtain that distinction.

Stimulated by this, he resumed work, in spite of ill health, and some of his most beautiful theorems, it is said, were discovered about this time. On the 13th October of the same year, he was elected a Fellow of the Trinity College, Cambridge—a prize fellowship worth

about £250 a year with no duties or conditions. In announcing this election, Mr. Hardy wrote to the Registrar of the University of Madras :—

He will return to India with a scientific standing and reputation such as no Indian has enjoyed before, and I am confident that India will regard him as the treasure he is.

RETURN TO INDIA AND DEATH

Ramanujan left England soon after, landing in Bombay on the 27th March 1919. His health at the time was precarious, and arrangements were made for careful nursing. But it was all of no avail and he succumbed on the 26th April 1920 at Chetput in Madras.

HIS CONTRIBUTIONS TO MATHEMATICS

Of Ramanujan's mathematical achievements, it is difficult to write, for they were highly technical. His papers include "a large number of mathematical formulae involving infinite series, integrals, continued fractions and also results in the theory of numbers." These give a clear indication of the peculiarity of Ramanujan's mathematical thought, which had an individuality all its own.

While by sheer force of inspiration, he scaled the heights of science his methods of

proof were somewhat antiquated.

The limitations of his knowledge were as startling as its profundity. Here was a man who could work out modular equations, and theorems of complex multiplication, to orders unheard of, whose mastery of continued fractions was, on the formal side at any rate, beyond that of any mathematician in the world, who had found for himself the functional equation of the Zeta-function, and the dominant terms of many of the most famous problems in the analytic theory of numbers; and he had never heard of a doubly periodic function or of Cauchy's Theorem, and had indeed, but the vaguest idea of what a function of a complex variable was. His ideas as to what constituted a mathematical proof were of the most shadowy description. All his results, new or old, right or wrong, had been arrived at by a process of mingled argument, intuition, and induction, of which he was entirely unable to give any coherent account.

But these drawbacks tended to disappear after the Cambridge course, and, under the genial influence of Prof. Hardy, he acquired in a couple of years "a fair knowledge of the theory of functions and the analytic theory on numbers", and his writings began to take distinctly fruitful directions.

The writer of these pages has no pretensions to a knowledge of the technics of Ramanujan's wonderful researches, and he must content himself, therefore, with drawing largely on the observations of "A Professor of Mathematics" who has given some indications of

the subject matter of the more important papers of Ramanujan.

The paper on "Modular Equations and Approximations to Pi" contains a series of remarkable algebraic approximations to Pi, the ratio of the circumference to the diameter of a circle. Several of Ramanujan's results had been anticipated by Hermite and Kronecker, but apart from these, Ramanujan gives many new formulae. Prof. Mordell gives an interesting historical account of the subject-matter of this paper in Appendix I, which contains also several other important notes on Ramanujan's papers likely to be of great use to future investigators. The paper on "Highly Composite Numbers" is the first long memoir that Ramanujan published on the theory of numbers, and it is a very characteristic piece of work. The idea of highly composite numbers—numbers, which, in some ways, may be regarded as the exact opposite of primes—is entirely new, and the skill with which Ramanujan investigates their properties by purely elementary methods is very remarkable. This paper and his later papers on partitions give an idea of his love of numbers for their own sake, a quality which evoked the remark (quoted by Prof. Hardy) that "every positive integer was one of his personal friends." Ramanujan's work on highly composite numbers stands somewhat apart from the main current of research in the analytic theory of numbers; but there is one place where it is likely to be of capital importance. The idea of superior highly composite numbers, which he introduces in the latter part of the paper, has a close relation to the determination of the maximum order of the number of divisors of a number, and this relation in its turn depends on the hypothesis of Riemann concerning the zeros of the Zeta-function. The next papers to which attention may be called are those entitled "On Certain Arithmetical Functions," "On Certain Trigonometrical Sums and their applications in the Theory of Numbers" and a few short notes on partitions and modular relations. These constitute Ramanujan's masterpieces, and contain the fullest expression of those characteristics, which were peculiarly his.

The tribute which Prof. Hardy pays to these qualities is worth quoting:

"It was his insight into algebraical formulæ, transformations of infinite series and so forth that was most amazing. On this side most certainly, I have never met his equal, and I can compare him only with Euler or Jacobi. He worked, far more than the majority of modern mathematicians, by induction from numerical examples; all of his congruence properties of partitions, for example, were discovered in this way. But with his memory, his patience and his power of calculation, he combined a power of generalisation, a feeling for form, and a capacity for rapid modification of his hypothesis, that were often really startling and made him, in his own peculiar field, without a rival in his day".

Professors of Mathematics have drawn attention to the influence of Ramanujan's writings apart from the sheer inspiration of his work. But what is of striking importance is that he was profoundly original. "It is often said" writes Mr. Hardy,

That it is much more difficult now for a mathematician to be original than it was in the great days when the foundations of modern analysis were laid; and no doubt in a measure it is true. Opinions may differ as to the importance of Ramanujan's work, the kind of standard by which it should be judged, and the influence which it is likely to have on the mathematics of the future. It has not the simplicity and the inevitableness of the very greatest work; it would be greater if it were less strange. One gift it has which no one can deny, profound and invincible originality.

RAMANUJAN, THE MAN & HIS CHARACTER

Those who have known Ramanujan intimately bear witness to the fact that he was utterly

devoid of any vanity or assumption. In a letter of date 26th November 1918, *i.e.*, after Ramanujan had been honoured by being elected a Fellow of the Royal Society and a Fellow of Trinity, Mr. Hardy wrote:—

His natural simplicity has never been affected in the least by his success; indeed all that is wanted is to get him to realise that he is really a success.

Mr. Hardy tells us that Ramanujan had very little interest outside Mathematics, and he could hardly distinguish good from bad art. On his return from England, we are told, he was very thin, pale and emaciated.

But his intellect was never dimmed, and till about four days before he died, he was engaged in work. All his work on "Mock Theta functions" of which only rough indications survive, was done on his death-bed.

Ramanujan had definite religious views. He was tenacious in his orthodoxy. He observed the caste rules with a punctiliousness most unusual among Indians in England: "but his religion was a matter of observance but not of intellectual conviction."

He believed in the existence of a Supreme Being and in the attainment of Godhood by men by proper methods of service and realisation of oneness with the Deity. He had settled convictions about the problem of life and after, even the certain approach of death did not unsettle his faculties or spirits.

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